XEROX

# Interlisp-D Reference Manual
# Volume III: Input/Output

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# 24. STREAMS AND FILES

Interlisp-D can perform input/output operations on a large variety of physical devices, including local disk drives, floppy disk drives, the keyboard and display screen, and remote file server computers accessed over a network. While the low-level details of how all these devices perform input/output vary considerably, the Interlisp-D language provides the programmer a small, common set of abstract operations whose use is largely independent of the physical input/output medium involved—operations such as *read*, *print*, *change font*, or *go to a new line*. By merely changing the targeted I/O device, a single program can be used to produce output on the display, a file, or a printer.

The underlying data abstraction that permits this flexibility is the *stream*. A stream is a data object (an instance of the data type **STREAM**) that encapsulates all of the information about an input/output connection to a particular I/O device. Each of Interlisp-D's general-purpose I/O functions takes a stream as one of its arguments. The general-purpose function then performs action specific to the stream's device to carry out the requested operation. Not every device is capable of implementing every I/O operation, while some devices offer additional functionality by way of special functions for that device alone. Such restrictions and extensions are noted in the documentation of each device.

The vast majority of the streams commonly used in Interlisp-D fall into two interesting categories: the *file stream* and the *image stream*.

A file is an ordered collection of data, usually a sequence of characters or bytes, stored on a file device in a manner that allows the data to be retrieved at a later time. Floppy disks, hard disks, and remote file servers are among the devices used to store files. Files are identified by a "file name", which specifies the device on which the file resides and a name unique to a specific file on that device. Input or output to a file is performed by obtaining a stream to the file, using **OPENSTREAM** (page 24.2). In addition, there are functions that manipulate the files themselves, rather than their data content.

An image stream is an output stream to a display device, such as the display screen or a printer. In addition to the standard output operations, such as print, an image stream implements a variety of graphics operations, such as drawing lines and displaying characters in multiple fonts. Unlike a file, the "content" of an image stream cannot be retrieved. Image streams are described on page 27.8.

The creation of other kinds of streams, such as network byte-stream connections, is described in the chapters peculiar to those kinds of streams. The operations common to streams in general are described on page 25.1. This chapter describes operations specific to file devices: how to name files, how to open streams to files, and how to manipulate files on their devices.

## 24.1 Opening and Closing File Streams

In order to perform input from or output to a file, it is necessary to create a stream to the file, using **OPENSTREAM**:

(**OPENSTREAM** *FILE ACCESS RECOG PARAMETERS* —) [Function]

Opens and returns a stream for the file specified by *FILE*, a file name. *FILE* can be either a string or a litatom. The syntax and manipulation of file names is described at length on page 24.5. Incomplete file names are interpreted with respect to the connected directory (page 24.10).

*RECOG* specifies the recognition mode of *FILE*, as described on page 24.12. If *RECOG* = **NIL**, it defaults according to the value of *ACCESS*.

*ACCESS* specifies the "access rights" to be used when opening the file, one of the following:

**INPUT** Only input operations are permitted on the file. The file must already exist. Starts reading at the beginning of the file. *RECOG* defaults to **OLD**.

**OUTPUT** Only output operations are permitted on the file. Starts writing at the beginning of the file, which is initially empty. While the file is open, other users or processes are unable to open the file for either input or output. *RECOG* defaults to **NEW**.

**BOTH** Both input and output operations are permitted on the file. Starts reading or writing at the beginning of the file. *RECOG* defaults to **OLD/NEW**. *ACCESS* = **BOTH** implies random accessibility (page 25.18), and thus may not be possible for files on some devices.

**APPEND** Only sequential output operations are permitted on the file. Starts writing at the *end* of the file. *RECOG* defaults to **OLD/NEW**. *ACCESS* = **APPEND** may not be allowed for files on some devices.

Note: *ACCESS* = **OUTPUT** implies that one intends to write a new or different file, even if a version number was specified and the corresponding file already exists. Thus any previous contents of the file are discarded, and the file is empty immediately after the **OPENSTREAM**. If it is desired to write on an already existing file while preserving the old contents, the file must be opened for access **BOTH** or **APPEND**.

*PARAMETERS* is a list of pairs (*ATTRIB VALUE*), where *ATTRIB* is any file attribute that the file system is willing to allow the user to set (see **SETFILEINFO**, page 24.17). A non-list *ATTRIB* in *PARAMETERS* is treated as the pair (*ATTRIB* **T**). Generally speaking, attributes that belong to the permanent file (e.g., **TYPE**) can only be set when creating a new file, while attributes that belong only to a particular opening of a file (e.g., **ENDOFSTREAMOP**) can be set on any call to **OPENSTREAM**. Not all devices honor all attributes; those not recognized by a particular device are simply ignored.

In addition to the attributes permitted by **SETFILEINFO**, the following tokens are accepted by **OPENSTREAM** as values of *ATTRIB* in its *PARAMETERS* argument:

**DON'T.CHANGE.DATE** If *VALUE* is non-**NIL**, the file's creation date (page 24.17) is not changed when the file is opened. This option is meaningful only for old files being opened for access **BOTH**. This should be used only for specialized applications in which the caller does not want the file system to believe the file's content has been changed.

**SEQUENTIAL** If *VALUE* is non-**NIL**, this opening of the file need support only sequential access; i.e., the caller intends never to use **SETFILEPTR**. For some devices, sequential access to files is much more efficient than random access. Note that the device may choose to ignore this attribute and still open the file in a manner that permits random access. Also note that this attribute does not make sense with *ACCESS* = **BOTH**.

If *FILE* is not recognized by the file system, **OPENSTREAM** causes the error **FILE NOT FOUND**. Ordinarily, this error is intercepted via an entry on **ERRORTYPELST** (page 14.22), which causes **SPELLFILE** (page 24.32) to be called. **SPELLFILE** searches alternate directories and possibly attempts spelling correction on the file name. Only if **SPELLFILE** is unsuccessful will the **FILE NOT FOUND** error actually occur.

If *FILE* exists but cannot be opened, **OPENSTREAM** causes one of several other errors: **FILE WON'T OPEN** if the file is already opened for conflicting access by someone else; **PROTECTION VIOLATION** if the file is protected against the operation; **FILE SYSTEM RESOURCES EXCEEDED** if there is no more room in the file system.

**(CLOSEF** ***FILE*****)** [Function]

Closes *FILE*, and returns its full file name. Generates an error, **FILE NOT OPEN**, if *FILE* does not designate an open stream. After closing a stream, no further input/output operations are permitted on it.

If *FILE* is **NIL**, it is defaulted to the primary input stream if that is not the terminal stream, or else the primary output stream if that is not the terminal stream. If both primary input and output streams are the terminal input/output streams, **CLOSEF** returns **NIL**. If **CLOSEF** closes either the primary input stream or the primary output stream (either explicitly or in the *FILE* = **NIL** case), it resets the primary stream for that direction to be the corresponding terminal stream. See page 25.3 for information on the primary input/output streams.

**WHENCLOSE** (page 24.20) allows the user to "advise" **CLOSEF** to perform various operations when a file is closed.

Because of buffering, the contents of a file open for output are not guaranteed to be written to the actual physical file device until **CLOSEF** is called. Buffered data can be forced out to a file without closing the file by using the function **FORCEOUTPUT** (page 25.10).

Some network file devices perform their transactions in the background. As a result, it is possible for a file to be closed by **CLOSEF** and yet not be "fully" closed for some small period of time afterward, during which time the file appears to still be busy, and cannot be opened for conflicting access by other users.

**(CLOSEF?** ***FILE*****)** [Function]

Closes *FILE* if it is open, returning the value of **CLOSEF**; otherwise does nothing and returns **NIL**.

In the present implementation of Interlisp-D, all streams to files are kept, while open, in a registry of "open files". This registry does not include nameless streams, such as string streams (page 24.28), display streams (page 28.29), and the terminal input and output streams; nor streams explicitly hidden from the user, such as dribble streams (page 30.12). This registry may not persist in future implementations of Interlisp-D, but at the present time it is accessible by the following two functions:

**(OPENP** ***FILE ACCESS*****)** [Function]

*ACCESS* is an access mode for a stream opening (one of **INPUT**, **OUTPUT**, **BOTH**, or **APPEND**), or **NIL**, meaning any access.

If *FILE* is a stream, returns its full name if it is open for the specified access, else **NIL**.

If *FILE* is a file name (a litatom), *FILE* is processed according to the rules of file recognition (page 24.12). If a stream open to a file by that name is registered and open for the specified access, then the file's full name is returned. If the file name is not recognized, or no stream is open to the file with the specified access, **NIL** is returned.

If *FILE* is **NIL**, returns a list of the full names of all registered streams that are open for the specified access.

**(CLOSEALL** *ALLFLG***)** [Function]

Closes all streams in the value of **(OPENP)**. Returns a list of the files closed.

**WHENCLOSE** (page 24.20) allows certain files to be "protected" from **CLOSEALL**. If *ALLFLG* is **T**, all files, including those protected by **WHENCLOSE**, are closed.

## 24.2 File Names

A file name in Interlisp-D is a string or litatom whose characters specify a "path" to the actual file: on what host or device the file resides, in which directory, and so forth. Because Interlisp-D supports a variety of non-local file devices, parts of the path could be very device-dependent. However, it is desirable for programs to be able to manipulate file names in a device-independent manner. To this end, Interlisp-D specifies a uniform file name syntax over all devices; the functions that perform the actual file manipulation for a particular device are responsible for any translation to that device's naming conventions.

A file name is composed of a collection of *fields*, some of which have specific semantic interpretations. The functions described below refer to each field by a ***field name***, a literal atom from among the following: **HOST**, **DEVICE**, **DIRECTORY**, **NAME**, **EXTENSION**, and **VERSION**. The standard syntax for a file name that contains all of those fields is **{HOST}DEVICE:<DIRECTORY>NAME.EXTENSION;VERSION**. Some host's file systems do not use all of those fields in their file names.

**HOST** Specifies the host whose file system contains the file. In the case of local file devices, the "host" is the name of the device, e.g., **DSK** or **FLOPPY**.

**DEVICE** Specifies, for those hosts that divide their file system's name space among mutiple physical devices, the device or logical structure on which the file resides. This should not be confused with Interlisp-D's abstract "file device", which denotes either a host or a local physical device and is specified by the **HOST** field.

**DIRECTORY** Specifies the "directory" containing the file. A directory usually is a grouping of a possibly large set of loosely related files, e.g., the personal files of a particular user, or the files belonging to some project. The **DIRECTORY** field usually consists of a principal directory and zero or more subdirectories that together describe a path through a file system's hierarchy. Each subdirectory name is set off from the previous directory or subdirectory by the character "**>**"; e.g., "**LISP>LIBRARY>NEW**".

**NAME** This field carries no specific meaning, but generally names a set of files thought of as being different renditions of the "same" abstract file.

**EXTENSION** This field also carries no specific meaning, but generally distinguishes the form of files having the same name. Most files systems have some "conventional" extensions that denote something about the content of the file. E.g., in Interlisp-D, the extension **DCOM** standardly denotes a file containing compiled function definitions.

**VERSION** A number used to distinguish the versions or "generations" of the files having a common name and extension. The version number is incremented each time a new file by the same name is created.

Most functions that take as input "a directory" accept either a directory name (the contents of the **DIRECTORY** field of a file name) or a "full" directory specification—a file name fragment consisting of only the fields **HOST**, **DEVICE**, and **DIRECTORY**. In particular, the "connected directory" (page 24.10) consists, in general, of all three fields.

For convenience in dealing with certain operating systems, Interlisp-D also recognizes **[]** and **()** as host delimiters (synonymous with **{}**), and / as a directory delimiter (synonymous with **<** at the beginning of a directory specification and **>** to terminate directory or subdirectory specification). For example, a file on a Unix file server **UNX** with the name **/usr/foo/bar/stuff.tedit**, whose **DIRECTORY** field is thus **usr/foo/bar**, could be specified as **{UNX}/usr/foo/bar/stuff.tedit**, or **(UNX)<usr/foo/bar>stuff.tedit**, or several other variations. Note that when using **[]** or **()** as host delimiters, they usually must be escaped with the reader's **%** escape character if the file name is expressed as a litatom rather than a string.

Different hosts have different requirements regarding which characters are valid in file names. From Interlisp-D's point of view, any characters are valid. However, in order to be able to parse a file name into its component fields, it is necessary that those characters that are conventionally used as file name delimiters be quoted when they appear inside of fields where there could be ambiguity. The file name quoting character is "'" (single quote). Thus, the following characters must be quoted when not used as delimeters: :, >, ;, /, and ' itself. The character . (period) need only be quoted if it is to be considered a part of the **EXTENSION** field. The characters }, ], and ) need only be quoted in a file name when the host field of the name is introduced by {, [, and (, respectively. The characters {, [, (, and < need only be quoted if they appear as the first character of a file name fragment, where they would otherwise be assumed to introduce the **HOST** or **DIRECTORY** fields.

The following functions are the standard way to manipulate file names in Interlisp. Their operation is purely syntactic—they perform no file system operations themselves.

**(UNPACKFILENAME.STRING** *FILENAME* — — —**)** [Function]

Parses *FILENAME*, returning a list in property list format of alternating field names and field contents. The field contents are returned as strings. If *FILENAME* is a stream, its full name is used.

Only those fields actually present in *FILENAME* are returned. A field is considered present if its delimiting punctuation (in the case of **EXTENSION** and **VERSION**, the preceding period or semicolon, respectively) is present, even if the field itself is empty. Empty fields are denoted by "" (the empty string).

Examples:

```
(UNPACKFILENAME.STRING "FOO.BAR") =>
  (NAME "FOO" EXTENSION "BAR")

(UNPACKFILENAME.STRING "FOO.;2") =>
  (NAME "FOO" EXTENSION "" VERSION "2")

(UNPACKFILENAME.STRING "FOO;") =>
  (NAME "FOO" VERSION "")

(UNPACKFILENAME.STRING
  "{ERIS}<LISP>CURRENT>IMTRAN.DCOM;21")
  => (HOST "ERIS" DIRECTORY "LISP>CURRENT"
    NAME "IMTRAN" EXTENSION "DCOM"
    VERSION "21")
```

**(UNPACKFILENAME** *FILE* —**)** [Function]

Old version of **UNPACKFILENAME.STRING** that returns the field values as atoms, rather than as strings. **UNPACKFILENAME.STRING** is now considered the "correct" way of unpacking file names, because it does not lose information when the contents of a field are numeric. For example,

```
(UNPACKFILENAME 'STUFF.TXT) =>
  (NAME STUFF EXTENSION TXT)
```

but

**(UNPACKFILENAME 'STUFF.029) => (NAME STUFF EXTENSION 29)**

Explicitly omitted fields are denoted by the atom **NIL**, rather than the empty string.

Note: Both **UNPACKFILENAME** and **UNPACKFILENAME.STRING** leave the trailing colon on the device field, so that the Tenex device **NIL:** can be distinguished from the absence of a device. Although **UNPACKFILENAME.STRING** is capable of making the distinction, it retains this behavior for backward compatibility. Thus,

**(UNPACKFILENAME.STRING '{TOAST}DSK:FOO) => (HOST "TOAST" DEVICE "DSK:" NAME "FOO")**

**(FILENAMEFIELD** *FILENAME FIELDNAME***)** [Function]

Returns, as an atom, the contents of the *FIELDNAME* field of *FILENAME*. If *FILENAME* is a stream, its full name is used.

**(PACKFILENAME.STRING** *FIELD*$_1$ *CONTENTS*$_1$ ... *FIELD*$_N$ *CONTENTS*$_N$**)** [NoSpread Function]

Takes a sequence of alternating field names and field contents (atoms or strings), and returns the corresponding file name, as a string.

If **PACKFILENAME.STRING** is given a single argument, it is interpreted as a list of alternating field names and field contents. Thus **PACKFILENAME.STRING** and **UNPACKFILENAME.STRING** operate as inverses.

If the same field name is given twice, the *first* occurrence is used.

The contents of the field name **DIRECTORY** may be either a directory name or a full directory specification as described above.

**PACKFILENAME.STRING** also accepts the "field name" **BODY** to mean that its contents should itself be unpacked and spliced into the argument list at that point. This feature, in conjunction with the rule that fields early in the argument list override later duplicates, is useful for altering existing file names. For example, to provide a default field, place **BODY** first in the argument list, then the default fields. To override a field, place the new fields first and **BODY** last.

If the value of the **BODY** field is a stream, its full name is used.

Examples:

**(PACKFILENAME.STRING 'DIRECTORY "LISP" 'NAME "NET") => "<LISP>NET"**

```
(PACKFILENAME.STRING 'NAME "NET"
  'DIRECTORY "{DSK}<LISPFILES>")
    => "{DSK}<LISPFILES>NET"

(PACKFILENAME.STRING 'DIRECTORY "{DSK}"
  'BODY "{TOAST}<FOO>BAR")
    => "{DSK}BAR"

(PACKFILENAME.STRING 'DIRECTORY "FRED"
  'BODY "{TOAST}<FOO>BAR")
    => "{TOAST}<FRED>BAR"

(PACKFILENAME.STRING 'BODY "{TOAST}<FOO>BAR"
  'DIRECTORY "FRED")
    => "{TOAST}<FOO>BAR"

(PACKFILENAME.STRING 'VERSION NIL
  'BODY "{TOAST}<FOO>BAR.DCOM;2")
    => "{TOAST}<FOO>BAR.DCOM"

(PACKFILENAME.STRING 'BODY "{TOAST}<FOO>BAR.DCOM"
  'VERSION 1)
    => "{TOAST}<FOO>BAR.DCOM;1"

(PACKFILENAME.STRING 'BODY "{TOAST}<FOO>BAR.DCOM;"
  'VERSION 1)
    => "{TOAST}<FOO>BAR.DCOM;"

(PACKFILENAME.STRING 'BODY "BAR.;1"
  'EXTENSION "DCOM")
    => "BAR.;1"

(PACKFILENAME.STRING 'BODY "BAR;1"
  'EXTENSION "DCOM")
    => "BAR.DCOM;1"
```

In the last two examples, note that in one case the extension is explicitly present in the body (as indicated by the preceding period), while in the other there is no indication of an extension, so the default is used.

**(PACKFILENAME** *$FIELD_1$ $CONTENTS_1$ ... $FIELD_N$ $CONTENTS_N$***)** [NoSpread Function]

The same as **PACKFILENAME.STRING**, except that it returns the file name as a litatom, instead of a string.

## 24.3 Incomplete File Names

In general, it is not necessary to pass a complete file name (one containing all the fields listed above) to functions that take a file name as argument. Interlisp supplies suitable defaults for certain fields, as described below. Functions that return names of actual files, however, always return the fully specified name.

If the version field is omitted from a file name, Interlisp performs version recognition, as described on page 24.11.

If the host, device and/or directory field are omitted from a file name, Interlisp defaults them with respect to the currently connected directory. The connected directory is changed by calling the function **CNDIR** or using the programmer's assistant command **CONN**.

Defaults are added to the partially specified name "left to right" until a host, device or directory field is encountered. Thus, if the connected directory is **{TWENTY}PS:<FRED>**, then

**BAR.DCOM** means
**{TWENTY}PS:<FRED>BAR.DCOM**

**<GRANOLA>BAR.DCOM** means
**{TWENTY}PS:<GRANOLA>BAR.DCOM**

**MTA0:<GRANOLA>BAR.DCOM** means
**{TWENTY}MTA0:<GRANOLA>BAR.DCOM**

**{THIRTY}<GRANOLA>BAR.DCOM** means
**{THIRTY}<GRANOLA>BAR.DCOM**

In addition, if the partially specified name contains a subdirectory, but no principal directory, then the subdirectory is appended to the connected directory. For example,

**ISO>BAR.DCOM** means
**{TWENTY}PS:<FRED>ISO>BAR.DCOM**

Or, if the connected directory is the Unix directory **{UNX}/usr/fred/**, then **iso/bar.dcom** means **{UNX}/usr/fred/iso/bar.dcom**, but **/other/bar.dcom** means **{UNX}/other/bar.dcom**.

**(CNDIR** ***HOST/DIR*****)** [Function]

Connects to the directory *HOST/DIR*, which can either be a directory name or a full directory specification including host and/or device. If the specification includes just a host, and the host supports directories, the directory is defaulted to the value of **(USERNAME)**; if the host is omitted, connection is made to another directory on the same host as before. If *HOST/DIR* is **NIL**, connects to the value of **LOGINHOST/DIR**.

**CNDIR** returns the full name of the now-connected directory. Causes an error, **Non-existent directory**, if *HOST/DIR* is not recognized as a valid directory.

Note that **CNDIR** does not necessarily require or provide any directory access privileges. Access privileges are checked when a file is opened.

**CONN** *HOST/DIR* [Prog. Asst. Command]

Convenient command form of **CNDIR** for use at the executive. Connects to *HOST/DIR*, or to the value of **LOGINHOST/DIR** if *HOST/DIR* is omitted. This command is undoable—undoing it causes the system to connect to the previously connected directory.

**LOGINHOST/DIR** [Variable]

**CONN** with no argument connects to the value of the variable **LOGINHOST/DIR**, initially **{DSK}**, but usually reset in the user's greeting file (page 12.1).

**(DIRECTORYNAME** *DIRNAME STRPTR —***)** [Function]

If *DIRNAME* is **T**, returns the full specification of the currently connected directory. If *DIRNAME* is **NIL**, returns the "login" directory specification (the value of **LOGINHOST/DIR**). For any other value of *DIRNAME*, returns a full directory specification if *DIRNAME* designates an existing directory (satisfies **DIRECTORYNAMEP**), otherwise **NIL**.

If *STRPTR* is **T**, the value is returned as an atom, otherwise it is returned as a string.

**(DIRECTORYNAMEP** *DIRNAME HOSTNAME***)** [Function]

Returns **T** if *DIRNAME* is recognized as a valid directory on host *HOSTNAME*, or on the host of the currently connected directory if *HOSTNAME* is **NIL**. *DIRNAME* may be either a directory name or a full directory specification containing host and/or device as well.

If *DIRNAME* includes subdirectories, this function may or may not pass judgment on their validity. Some hosts support "true" subdirectories, distinct entities manipulable by the file system, while others only provide them as a syntactic convenience.

**(HOSTNAMEP** *NAME***)** [Function]

Returns **T** if *NAME* is recognized as a valid host or file device name at the moment **HOSTNAMEP** is called.

## 24.4 Version Recognition

Most of the file devices in Interlisp support file version numbers. That is, it is possible to have several files of the exact same name, differing only in their **VERSION** field, which is incremented for each new "version" of the file that is created. When a file name lacking a version number is presented to the file system, it is necessary to determine which version number is intended. This process is known as *version recognition*.

When **OPENSTREAM** opens a file for input and no version number is given, the highest existing version number is used. Similarly, when a file is opened for output and no version number is given, a new file is created with a version number one higher than the highest one currently in use with that file name. The version number defaulting for **OPENSTREAM** can be changed by specifying a different value for its *RECOG* argument, as described under **FULLNAME**, below.

Other functions that accept file names as arguments generally perform the default version recognition, which is newest version for existing files, or a new version if using the file name to create a new file. The one exception is **DELFILE**, which defaults to the oldest existing version of the file.

The functions below can be used to perform version recognition without actually calling **OPENSTREAM** to open the file. Note that these functions only tell the truth about the moment at which they are called, and thus cannot in general be used to anticipate the name of the file opened by a comparable **OPENSTREAM**. They are sometimes, however, helpful hints.

**(FULLNAME** ***X RECOG*****)** [Function]

If *X* is an open stream, simply returns the full file name of the stream. Otherwise, if *X* is a file name given as a string or litatom, performs version recognition, as follows:

If *X* is recognized in the recognition mode specified by *RECOG* as an abbreviation for some file, returns the file's full name, otherwise **NIL**. *RECOG* is one of the following:

**OLD** Choose the newest existing version of the file. Return **NIL** if no file named *X* exists.

**OLDEST** Choose the oldest existing version of the file. Return **NIL** if no file named *X* exists.

**NEW** Choose a new (not yet existing) version of the file. That is, if versions of *X* already exist, then choose a version number one higher than highest existing version; else choose version 1. For some file systems, **FULLNAME** returns **NIL** if the user does not have the access rights necessary for creating a new file named *X*.

**OLD/NEW** Try **OLD**, then **NEW**. That is, choose the newest existing version of the file, if any; else choose version 1. This usually only makes sense if you are intending to open *X* for access **BOTH**.

*RECOG* = **NIL** defaults to **OLD**. For all other values of *RECOG*, generates an error **ILLEGAL ARG**.

If *X* already contains a version number, the *RECOG* argument will never change it. In particular, *RECOG* = **NEW** does not require that the file actually be new. For example, **(FULLNAME 'FOO.;2 'NEW)** may return **{ERIS}<LISP>FOO.;2** if that file already exists, even though **(FULLNAME 'FOO 'NEW)** would default the version to a new number, perhaps returning **{ERIS}<LISP>FOO.;5**.

**(INFILEP *FILE*)** [Function]

Equivalent to **(FULLNAME *FILE* 'OLD)**. That is, returns the full file name of the newest version of *FILE* if *FILE* is recognized as specifying the name of an existing file that could potentially be opened for input, **NIL** otherwise.

**(OUTFILEP *FILE*)** [Function]

Equivalent to **(FULLNAME *FILE* 'NEW)**.

Note that **INFILEP**, **OUTFILEP** and **FULLNAME** do not open any files; they are pure predicates. In general they are also only hints, as they do not necessarily imply that the caller has access rights to the file. For example, **INFILEP** might return non-**NIL**, but **OPENSTREAM** might fail for the same file because the file is read-protected against the user, or the file happens to be open for output by another user at the time. Similarly, **OUTFILEP** could return non-**NIL**, but **OPENSTREAM** could fail with a **FILE SYSTEM RESOURCES EXCEEDED** error.

Note also that in a shared file system, such as a remote file server, intervening file operations by another user could contradict the information returned by recognition. For example, a file that was **INFILEP** might be deleted, or between an **OUTFILEP** and the subsequent **OPENSTREAM**, another user might create a new version or delete the highest version, causing **OPENSTREAM** to open a different version of the file than the one returned by **OUTFILEP**. In addition, some file servers do not well support recognition of files in output context. Thus, in general, the "truth" about a file can only be obtained by actually opening the file; creators of files should rely on the name of the stream opened by **OPENSTREAM**, not the value returned from these recognition functions. In particular, for the reasons described earlier, programmers are discouraged from using **OUTFILEP** or **(FULLNAME *NAME* 'NEW)**.

## 24.5 Using File Names Instead of Streams

In earlier implementations of Interlisp, from the days of Interlisp-10 onward, the "handle" used to refer to an open file was not a stream, but rather the file's full name, represented as a litatom. When the file name was passed to any I/O function, it was mapped to a stream by looking it up in a list of open files. This scheme was sometimes convenient for typing in file commands at the executive, but was very poor for serious programming in two major ways. First, the mapping from file name to stream on every input/output operation is inefficient. Second, and more importantly, using the file name as the handle on an open stream means that it is not possible to have more than one stream open on a given file at once.

As of this writing, Interlisp-D is in a transition period, where it still supports the use of litatom file names as synonymous with open streams, but this use is not recommended. The remainder of this section discusses this usage of file names for the benefit of those reading older programs and wishing to convert them as necessary to work properly when this compatibility feature is removed.

## 24.5.1 File Name Efficiency Considerations

It is possible for a program to be seriously inefficient using a file name as a stream if the program is not using the file's full name, the name returned by **OPENFILE** (below). Any time that an input/output function is called with a file name other than the full file name, Interlisp must perform recognition on the partial file name in order to determine which open file is intended. Thus if repeated operations are to be performed, it is considerably more efficient to use the full file name returned from **OPENFILE** than to repeatedly use the possibly incomplete name that was used to open the file.

There is a more subtle problem with partial file names, in that recognition is performed on the user's entire directory, not just the open files. It is possible for a file name that was previously recognized to denote one file to suddenly denote a different file. For example, suppose a program performs **(INFILE 'FOO)**, opening **FOO.;1**, and reads several expressions from **FOO**. Then the user interrupts the program, creates a **FOO.;2** and resumes the program (or a user at another workstation creates a **FOO.;2**). Now a call to **READ** giving it **FOO** as its *FILE* argument will generate a **FILE NOT OPEN** error, because **FOO** will be recognized as **FOO.;2**.

## 24.5.2 Obsolete File Opening Functions

The following functions are now considered obsolete, but are provided for backwards compatibility:

**(OPENFILE** *FILE ACCESS RECOG PARAMETERS* **—)** [Function]

Opens *FILE* with access rights as specified by *ACCESS*, and recognition mode *RECOG*, and returns the full name of the resulting stream. Equivalent to **(FULLNAME (OPENSTREAM** *FILE ACCESS RECOG PARAMETERS***))**.

**(INFILE** *FILE***)** [Function]

Opens *FILE* for input, and sets it as the primary input stream. Equivalent to **(INPUT (OPENSTREAM** *FILE* **'INPUT 'OLD))**

**(OUTFILE** *FILE***)** [Function]

Opens *FILE* for output, and sets it as the primary output stream. Equivalent to **(OUTPUT (OPENSTREAM** *FILE* **'OUTPUT 'NEW))**.

**(IOFILE** *FILE***)** [Function]

Equivalent to **(OPENFILE** *FILE* **'BOTH 'OLD)**; opens *FILE* for both input and output. Does not affect the primary input or output stream.

## 24.5.3 Converting Old Programs

At some point in the future, the Interlisp-D file system will change so that each call to **OPENSTREAM** returns a distinct stream, even if a stream is already open to the specified file. This change is required in order to deal rationally with files in a multiprocessing environment.

This change will of necessity produce the following incompatibilities:

1) The functions **OPENFILE, INPUT**, and **OUTPUT** will return a **STREAM**, not a full file name. To make this less confusing in interactive situations, **STREAMs** will have a print format that reveals the underlying file's actual name,

2) A greater penalty will ensue for passing as the *FILE* argument to i/o operations anything other than the object returned from **OPENFILE**. Passing the file's name will be significantly slower than passing the stream (even when passing the "full" file name), and in the case where there is more than one stream open on the file it might even act on the wrong one.

3) **OPENP** will return **NIL** when passed the name of a file rather than a stream (the value of **OPENFILE** or **OPENSTREAM**).

Users should consider the following advice when writing new programs and editing existing programs, in order that they will continue to operate well when this change is made:

Because of the efficiency and ambiguity considerations described earlier, users have long been encouraged to use only full file names as *FILE* arguments to i/o operations. The "proper" way to have done this was to bind a variable to the value returned from **OPENFILE** and pass that variable to all i/o operations; such code will continue to work. A less proper way to obtain the full file name, but one which has to date not incurred any obvious penalty, is that which binds a variable to the result of an **INFILEP** and passes that to **OPENFILE** and all i/o operations. This has worked because **INFILEP** and **OPENFILE** both return a full file name, an invalid assumption in this future world. Such code should be changed to pass around the value of the **OPENFILE**, not the **INFILEP**.

Code that calls **OPENP** to test whether a possibly incomplete file name is already open should be recoded to pass to **OPENP** only the value returned from **OPENFILE** or **OPENSTREAM**.

Code that uses ordinary string functions to manipulate file names, and in particular the value returned from **OPENFILE**, should be changed to use the the functions **UNPACKFILENAME.STRING** and **PACKFILENAME.STRING**. Those functions work both on file names (strings) and streams (coercing the stream to the name of its file).

Code that tests the value of **OUTPUT** for equality to some known file name or **T** should be examined carefully and, if possible, recoded.

To see more directly the effects of passing around **STREAM**s instead of file names, replace your calls to **OPENFILE** with calls to **OPENSTREAM**. **OPENSTREAM** is called in exactly the same way, but returns a **STREAM**. Streams can be passed to **READ**, **PRINT**, **CLOSEF**, etc just as the file's full name can be currently, but using them is more efficient. The function **FULLNAME**, when applied to a stream, returns its full file name.

## 24.6 Using Files with Processes

Because Interlisp-D does not yet support multiple streams per file, problems can arise if different processes attempt to access the same file. The user has to be careful not to have two processes manipulating the same file at the same time, since the two processes will be sharing a single input stream and file pointer. For example, it will not work to have one process **TCOMPL** a file while another process is running **LISTFILES** on it.

## 24.7 File Attributes

Any file has a number of "file attributes", such as the read date, protection, and bytesize. The exact attributes that a file can have is dependent on the file device. The functions **GETFILEINFO** and **SETFILEINFO** allow the user to conveniently access file attributes:

**(GETFILEINFO** *FILE ATTRIB***)** [Function]

Returns the current setting of the *ATTRIB* attribute of *FILE*.

**(SETFILEINFO** *FILE ATTRIB VALUE***)** [Function]

Sets the attribute *ATTRIB* of *FILE* to be *VALUE*. **SETFILEINFO** returns **T** if it is able to change the attribute *ATTRIB*, and **NIL** if unsuccessful, either because the file device does not recognize *ATTRIB* or because the file device does not permit the attribute to be modified.

The *FILE* argument to **GETFILEINFO** and **SETFILEINFO** can be an open stream (or an argument designating an open stream, see page 25.2), or the name of a closed file. **SETFILEINFO** in general requires write access to the file.

The attributes recognized by **GETFILEINFO** and **SETFILEINFO** fall into two categories: *permanent* attributes, which are properties of the file, and *temporary* attributes, which are properties only of an open stream to the file. The temporary attributes are only recognized when *FILE* designates an open stream; the permanent attributes are usually equally accessible for open and closed files. However, some devices are willing to change the value of certain attributes of an open stream only when specified in the *PARAMETERS* argument to **OPENSTREAM** (page 24.2), not on a later call to **SETFILEINFO**.

The following are currently recognized as permanent attributes of a file:

**BYTESIZE** The byte size of the file. Interlisp-D currently only supports byte size 8.

**LENGTH** The number of bytes in the file. Alternatively, the byte position of the end-of-file. Like **(GETEOFPTR** *FILE***)**, but *FILE* does not have to be open.

**SIZE** The size of *FILE* in pages.

**CREATIONDATE** The date and time, as a string, that the content of *FILE* was "created". The creation date changes whenever the content of the file is modified, but remains unchanged when a file is transported, unmodified, across file systems. Specifically, **COPYFILE** and **RENAMEFILE** (page 24.31) preserve the file's creation date. Note that this is different from the concept of "creation date" used by some operating systems (e.g., Tops20).

**WRITEDATE** The date and time, as a string, that the content of *FILE* was last written to this particular file system. When a file is copied, its creation date does not change, but its write date becomes the time at which the copy is made.

**READDATE** The date and time, as a string, that *FILE* was last read, or **NIL** if it has never been read.

**ICREATIONDATE**
**IWRITEDATE**
**IREADDATE** The **CREATIONDATE, WRITEDATE** and **READDATE**, respectively, in integer form, as **IDATE** (page 12.14) would return. This form is useful for comparing dates.

**AUTHOR** The name of the user who last wrote the file.

**TYPE** The "type" of the file, some indication of the nature of the file's content. The "types" of files allowed depends on the file device. Most devices recognize the litatom **TEXT** to mean that the file contains just characters, or **BINARY** to mean that the file contains arbitrary data.

Some devices support a wider range of file types that distinguish among the various sorts of files one might create whose content is "binary". All devices interpret any value of **TYPE** that they do not support to be **BINARY**. Thus, **GETFILEINFO** may return the more general value **BINARY** instead of the original type that was passed to **SETFILEINFO** or **OPENSTREAM**. Similarly, **COPYFILE**, while attempting to preserve the **TYPE** of the file it is copying, may turn, say, an **INTERPRESS** file into a mere **BINARY** file.

The way in which some file devices (e.g., Xerox file servers) support a wide range of file types is by representing the type as an integer, whose interpretation is known by the client. The variable **FILING.TYPES** is used to associate symbolic types with numbers for these devices. This list initially contains some of the well-known assignments of type name to number; the user can add additional elements to handle any private file types. For example, suppose there existed an NS file type **MAZEFILE** with numeric value 5678. You could add the element **(MAZEFILE 5678)** to **FILING.TYPES** and then use **MAZEFILE** as a value for the **TYPE** attribute to **SETFILEINFO** or **OPENSTREAM**. Other devices are, of course, free to store **TYPE** attributes in whatever manner they wish, be it numeric or symbolic. **FILING.TYPES** is merely considered the official registry for Xerox file types.

For most file devices, the **TYPE** of a newly created file, if not specified in the *PARAMETERS* argument to **OPENSTREAM**, defaults to the value of **DEFAULTFILETYPE**, initially **TEXT**.

The following are currently recognized as temporary attributes of an open stream:

**ACCESS** The current access rights of the stream (see page 24.2). Can be one of **INPUT**, **OUTPUT**, **BOTH**, **APPEND**; or **NIL** if the stream is not open.

**ENDOFSTREAMOP** The action to be taken when a stream is at "end of file" and an attempt is made to take input from it. The value of this attribute is a function of one argument, the stream. The function can examine the stream and its calling context and take any action it wishes. If the function returns normally, its should return either **T**, meaning to try the input operation again, or the byte that **BIN** would have returned had there been more bytes to read. Ordinarily, one should not let the **ENDOFSTREAMOP** function return unless one is only performing binary input from the file, since there is no way in general of knowing in what state the reader was at the time the end of file occurred, and hence how it will interpret a single byte returned to it.

The default **ENDOFSTREAMOP** is a system function that causes the error **END OF FILE**. The behavior of that error can be further modified for a particular stream by using the **EOF** option of **WHENCLOSE** (page 24.20).

**EOL** The end-of-line convention for the stream. This can be **CR**, **LF**, or **CRLF**, indicating with what byte or sequence of bytes the "End Of Line" character is represented on the stream. On input, that sequence of bytes on the stream is read as **(CHARCODE EOL)** by **READCCODE** or the string reader. On output, **(TERPRI)** and **(PRINTCCODE (CHARCODE EOL))** cause that sequence of bytes to be placed on the stream.

The end of line convention is usually not apparent to the user. The file system is usually aware of the convention used by a particular remote operating system, and sets this attribute accordingly. If you believe a file actually is stored with a different convention than the default, it is possible to modify the default behavior by including the **EOL** attribute in the *PARAMETERS* argument to **OPENSTREAM**.

**BUFFERS** Value is the number of 512-byte buffers that the stream maintains at one time. This attribute is only used by certain random-access devices (currently, the local disk, floppy, and Leaf servers); all others ignore it.

Streams open to files generally maintain some portion of the file buffered in memory, so that each call to an I/O function does not require accessing the actual file on disk or a file server. For files being read or written sequentially, not much buffer space is needed, since once a byte is read or written, it will never need to be seen again. In the case of random access streams, buffering is more complicated, since a program may jump around in the file, using **SETFILEPTR** (page 25.19). In this case, the more buffer space the stream has, the more likely it is that after a **SETFILEPTR** to a place in the file that has already been accessed, the stream still has that part of the file buffered and need not go out to the device again. This benefit must, of course, be traded off against the amount of memory consumed by the buffers.

## 24.8 Closing and Reopening Files

The function **WHENCLOSE** permits the user to associate certain operations with open streams that govern how and when the stream will be closed. The user can specify that certain functions will be executed before **CLOSEF** closes the stream and/or after **CLOSEF** closes the stream. The user can make a particular stream be invisible to **CLOSEALL**, so that it will remain open across user invocations of **CLOSEALL**.

**(WHENCLOSE** *FILE PROP*$_1$ *VAL*$_1$ ... *PROP*$_N$ *VAL*$_N$**)** [NoSpread Function]

*FILE* must designate an open stream other than **T** (**NIL** defaults to the primary input stream, if other than **T**, or primary output stream if other than **T**). The remaining arguments specify properties to be associated with the full name of *FILE*. **WHENCLOSE** returns the full name of *FILE* as its value.

**WHENCLOSE** recognizes the following property names:

**BEFORE** *VAL* is a function that **CLOSEF** will apply to the stream just before it is closed. This might be used, for example, to copy information about the file from an in-core data structure to the file just before it is closed.

**AFTER** *VAL* is a function that **CLOSEF** will apply to the stream just after it is closed. This capability permits in-core data structures that know about the stream to be cleaned up when the stream is closed.

**CLOSEALL** *VAL* is either **YES** or **NO** and determines whether *FILE* will be closed by **CLOSEALL** (**YES**) or whether **CLOSEALL** will ignore it (**NO**). **CLOSEALL** uses **CLOSEF**, so that any **AFTER** functions will be executed if the stream is in fact closed. Files are initialized with **CLOSEALL** set to **YES**.

**EOF** *VAL* is a function that will be applied to the stream when an end-of-file error occurs, and the **ERRORTYPELST** entry for that error, if any, returns **NIL**. The function can examine the context of the error, and can decide whether to close the stream, **RETFROM** some function, or perform some other computation. If the function supplied returns normally (i.e., does not **RETFROM** some function), the normal error machinery will be invoked.

The default **EOF** behavior, unless overridden by this **WHENCLOSE** option, is to call the value of **DEFAULTEOFCLOSE** (below).

For some applications, the **ENDOFSTREAMOP** attribute (page 24.19) is a more useful way to intercept the end-of-file error. The **ENDOFSTREAMOP** attribute comes into effect before the error machinery is ever activated.

Multiple **AFTER** and **BEFORE** functions may be associated with a file; they are executed in sequence with the most recently associated function executed first. The **CLOSEALL** and **EOF** values, however, will override earlier values, so only the last value specified will have an effect.

**DEFAULTEOFCLOSE** [Variable]

Value is the name of a function that is called by default when an end of file error occurs and no **EOF** option has been specified for the stream by **WHENCLOSE**. The initial value of **DEFAULTEOFCLOSE** is **NILL**, meaning take no special action (go ahead and cause the error). Setting it to **CLOSEF** would cause the stream to be closed before the rest of the error machinery is invoked.

## 24.9 Local Hard Disk Device

*Warning: This section describes the Interlisp-D functions that control the local hard disk drive available on some computers. All of these functions may not work on all computers running Interlisp-D. For more information on using the local hard disk facilities, see the users guide for your computer.*

This section describes the local file system currently supported on the Xerox 1108 and 1186 computers. The Xerox 1132 supports a simpler local file system. The functions below are no-ops on the Xerox 1132, except for **DISKPARTITION** (which returns a disk partition number), and **DISKFREEPAGES**. On the Xerox 1132, different numbered partitions are referenced by using devices such as **{DSK1}**, **{DSK2}**, etc. **{DSK}** always refers to the disk partition that Interlisp is running on. The 1132 local file system does not support the use of directories.

The hard disk used with the Xerox 1108 or 1186 may be partitioned into a number of named "logical volumes." Logical volumes may be used to hold the Interlisp virtual memory file (see page 12.6), or Interlisp files. For information on intializing and partitioning the hard disk, see the users guide for your computer. In order to store Interlisp files on a logical volume, it is necessary to create a lisp file directory on that volume (see **CREATEDSKDIRECTORY**, below).

So long as there exists a logical volume with a Lisp directory on it, files on this volume can be accessed by using the file device called **{DSK}**. Interlisp-D can be used to read, write, and otherwise interact with files on local disk disks through standard Interlisp input/output functions. All I/O functions such as **LOAD**, **OPENSTREAM**, **READ**, **PRINT**, **GETFILEINFO**, **COPYFILE**, etc., work with files on the local disk.

If you do not have a logical volume with a Lisp directory on it, Interlisp emulates the **{DSK}** device by a core device, a file device whose backing store is entirely within the Lisp virtual memory. However, this is not recommended because the core device only provides limited scratch space, and since the core device is contained in virtual memory, it (and the files stored on it) will be erased when the virtual memory file is reloaded.

Each logical volume with a Lisp directory on it serves as a directory of the device **{DSK}**. Files are referred to by forms such as

**{DSK}<***VOLUMENAME***>***FILENAME*

Thus, the file **INIT.LISP** on the volume **LISPFILES** would be called **{DSK}<LISPFILES>INIT.LISP**.

Subdirectories within a logical volume are supported, using the > character in file names to delimit subdirectory names. For example, the file name **{DSK}<LISPFILES>DOC>DESIGN.TEDIT** designates the file names **DESIGN.TEDIT** on the subdirectory **DOC** on the logical volume **LISPFILES**.

If a logical volume name is not specified, it defaults in an unusual but simple way: the logical volume defaults to the next logical volume that has a lisp file directory on it including or after the volume containing the currently running virtual memory. For example, if the local disk has the logical volumes **LISP**, **TEMP**, and **LISPFILES**, the **LISP** volume contains the running virtual memory, and only the **LISP** volume has a Lisp file directory on it, then **{DSK}INIT.LISP** refers to the file **{DSK}<LispFiles>INIT.LISP**. All the functions below default logical volume names in a similar way, except for those such as **CREATEDSKDIRECTORY**. To determine the current default lisp file directory, evaluate **(DIRECTORYNAME '{DSK})**.

**(CREATEDSKDIRECTORY** *VOLUMENAME* **—)** [Function]

Creates a lisp file directory on the logical volume *VOLUMENAME*, and returns the name of the directory created. It is only necessary to create a lisp file directory the first time the logical volume is used. After that, the system automatically recognizes and opens access to the logical volumes that have lisp file directories on them.

**(PURGEDSKDIRECTORY** *VOLUMENAME* **—)** [Function]

Erases all lisp files on the volume *VOLUMENAME*, and deletes the lisp file directory.

**(LISPDIRECTORYP** ***VOLUMENAME*****)** [Function]

Returns **T** if the logical volume *VOLUMENAME* has a lisp file directory on it.

**(VOLUMES)** [Function]

Returns a list of the names of all of the logical volumes on the local hard disk (whether they have lisp file directories or not).

**(VOLUMESIZE** ***VOLUMENAME —*****)** [Function]

Returns the total size of the logical volume *VOLUMENAME* in disk pages.

**(DISKFREEPAGES** ***VOLUMENAME —*****)** [Function]

Returns the total number of free disk pages left on the logical volume *VOLUMENAME*.

**(DISKPARTITION)** [Function]

Returns the name of the logical volume containing the virtual memory file that Interlisp is currently running in (see page 12.6).

**(DSKDISPLAY** ***NEWSTATE*****)** [Function]

Controls a display window that displays information about the logical volumes on the local hard disk (logical volume names, sizes, free pages, etc.). **DSKDISPLAY** opens or closes this display window depending on the value of *NEWSTATE* (one of **ON**, **OFF**, or **CLOSED**), and returns the previous state of the display window.

If *NEWSTATE* is **ON**, the display window is opened, and it is automatically updated whenever the file system state changes (this can slow file operations significantly). If *NEWSTATE* is **OFF**, the display window is opened, but it is not automatically updated. If *NEWSTATE* is **CLOSED**, the display window is closed. The display mode is initially set to **CLOSED**.

Once the display window is open, the user can update it or change its state with the mouse. Left-buttoning the display window updates it, and middle-buttoning the window brings up a menu that allows you to change the display state.

Note: **DSKDISPLAY** uses the value of the variable **DSKDISPLAY.POSITION** for the position of the lower-left corner of the disk display window when it is opened. This variable is changed if the disk display window is moved.

**(SCAVENGEDSKDIRECTORY** ***VOLUMENAME SILENT*****)** [Function]

Rebuilds the lisp file directory for the logical volume *VOLUMENAME*. This may repair damage in the unlikely event of file system failure, signified by symptoms such as infinite looping or other strange behavior while the system is doing a directory search. Calling **SCAVENGEDSKDIRECTORY** will not harm an intact volume.

Normally, **SCAVENGEDSKDIRECTORY** prints out messages as it scavenges the directory. If *SILENT* is non-**NIL**, these messages are not printed.

Note: Some low-level disk failures may cause "**HARD DISK ERROR**" errors to occur. To fix such a failure, it may be necessary to log out of Interlisp, scavenge the logical volume in question using Pilot tools, and then call **SCAVENGEDSKDIRECTORY** from within Interlisp. See the users guide for your computer for more information.

## 24.10 Floppy Disk Device

*Warning: This section describes the Interlisp-D functions that control the floppy disk drive available on some computers. All of these functions may not work on all computers running Interlisp-D. For more information on using the floppy disk facilities, see the users guide for your computer.*

The floppy disk drive is accessed through the device **{FLOPPY}**. Interlisp-D can be used to read, write, and otherwise interact with files on floppy disks through standard Interlisp input/output functions. All I/O functions such as **LOAD**, **OPENSTREAM**, **READ**, **PRINT**, **GETFILEINFO**, **COPYFILE**, etc., work with files on floppies.

Note that floppy disks are a removable storage medium. Therefore, it is only meaningful to perform i/o operations to the floppy disk drive, rather than to a given floppy disk. In this section, the phrase "the floppy" is used to mean "the floppy that is currently in the floppy disk drive."

For example, the following sequence could be used to open a file **XXX.TXT** on the floppy, print "Hello" on it, and close it:

```
(SETQ XXX (OPENSTREAM '{FLOPPY}XXX.TXT 'OUTPUT 'NEW)
(PRINT "Hello" XXX)
(CLOSEF XXX)
```

**(FLOPPY.MODE *MODE*)** [Function]

Interlisp-D can currently read and write files on floppies stored in a number of different formats. At any point, the floppy is considered to be in one of four "modes," which determines how it reads and writes files on the floppy. **FLOPPY.MODE** sets the floppy mode to the value of *MODE*, one of **PILOT**, **HUGEPILOT**, **SYSOUT**, or **CPM**, and returns the previous floppy mode. The floppy modes are interpreted as follows:

**PILOT** This is the normal floppy mode, using floppies in the Xerox Pilot floppy disk format. This file format allows all of the normal Interlisp-D I/O operations. This format also supports file names with arbitrary levels of subdirectories. For example, it is possible to create a file named **{FLOPPY}<Lisp>Project>FOO.TXT**.

**HUGEPILOT** This floppy mode is used to access files that are larger than a single floppy, stored on multiple floppies. There are some restrictions with using "huge" files. Some I/O operations are not meaningful for "huge" files. When a stream is created for output in this mode, the **LENGTH** file attribute (page 24.17) must be specified when the file is opened, so that it is known how many floppies will be needed. When an output file is created, the floppy (or floppies) are automatically erased and reformatted (after confirmation from the user).

**HUGEPILOT** mode is primarily useful for saving big files to and from floppies. For example, the following could be used to copy the file **{ERIS}<Lisp>Bigfile.txt** onto the huge Pilot file **{FLOPPY}BigFile.save**:

```
(FLOPPY.MODE 'HUGEPILOT)
(COPYFILE '{ERIS}<Lisp>Bigfile.txt '{FLOPPY}BigFile.save)
```

and the following would restore the file:

```
(FLOPPY.MODE 'HUGEPILOT)
(COPYFILE '{FLOPPY}BigFile.save '{ERIS}<Lisp>Bigfile.txt)
```

During each copying operation, the user will be prompted to insert "the next floppy" if **{ERIS}<Lisp>Bigfile.txt** takes multiple floppies.

**SYSOUT** Similar to **HUGEPILOT** mode, **SYSOUT** mode is used for storing sysout files (page 12.8) on multiple floppy disks. The user is prompted to insert new floppies as they are needed.

This mode is set automatically when **SYSOUT** or **MAKESYS** is done to the floppy device: **(SYSOUT '{FLOPPY})** or **(MAKESYS '{FLOPPY})**. Notice that the file name does not need to be specifed in **SYSOUT** mode; unlike **HUGEPILOT** mode, the file name **Lisp.sysout** is always used.

Note: The procedure for loading sysout files from floppies depends on the particular computer being used. For information on loading sysout files from floppies, see the users guide for your computer.

Explicitly setting the mode to **SYSOUT** is useful when copying a sysout file to or from floppies. For example, the following can be used to copy the sysout file **{ERIS}<Lisp>Lisp.sysout** onto floppies (it is important to set the floppy mode back when done):

```
(FLOPPY.MODE 'SYSOUT)
(COPYFILE '{ERIS}<Lisp>Lisp.sysout '{FLOPPY})
```

**(FLOPPY.MODE 'PILOT)**

**CPM** Interlisp-D supports the single-density single-sided (SDSS) CPM floppy format (a standard used by many computers). CPM-formatted floppies are totally different than Pilot floppies, so the user should call **FLOPPY.MODE** to switch to **CPM** mode when planning to use CPM floppies. After switching to **CPM** mode, **FLOPPY.FORMAT** can be used to create CPM-formatted floppies, and the usual input/output operations work with CPM floppy files.

Note: There are a few limitations on CPM floppy format files: (1) CPM file names are limited to eight or fewer characters, with extensions of three or fewer characters; (2) CPM floppies do not have directories or version numbers; and (3) CPM files are padded out with blanks to make the file lengths multiples of 128.

**(FLOPPY.FORMAT** *NAME AUTOCONFIRMFLG SLOWFLG***)** [Function]

**FLOPPY.FORMAT** erases and initializes the track information on a floppy disk. This must be done when new floppy disks are to be used for the first time. This can also be used to erase the information on used floppy disks.

*NAME* should be a string that is used as the name of the floppy (106 characters max). This name can be read and set using **FLOPPY.NAME** (below).

If *AUTOCONFIRMFLG* is **NIL**, the user will be prompted to confirm erasing the floppy, if it appears to contain valid information. If *AUTOCONFIRMFLG* is **T**, the user is not prompted to confirm.

If *SLOWFLG* is **NIL**, only the Pilot records needed to give your floppy an empty directory are written. If *SLOWFLG* is **T**, **FLOPPY.FORMAT** will completely erase the floppy, writing track information and critical Pilot records on it. *SLOWFLG* should be set to **T** when formatting a brand-new floppy.

Note: Formatting a floppy is a very compute-intensive operation for the I/O hardware. Therefore, the cursor may stop tracking the mouse and keystrokes may be lost while formatting a floppy. This behavior goes away when the formatting is finished.

Warning: The floppy mode set by **FLOPPY.MODE** (above) affects how **FLOPPY.FORMAT** formats the floppy. If the floppy is going to be used in Pilot mode, it should be formatted under **(FLOPPY.MODE 'PILOT)**. If it is to be used as a CMP floppy, it should be formatted under **(FLOPPY.MODE 'CPM)**. The two types of formatting are incompatible.

**(FLOPPY.NAME** ***NAME*****)** [Function]

If *NAME* is **NIL**, returns the name stored on the floppy disk. If *NAME* is non-**NIL**, then the name of the floppy disk is set to *NAME*.

**(FLOPPY.FREE.PAGES)** [Function]

Returns the number of unallocated free pages on the floppy disk in the floppy disk drive.

Note: Pilot floppy files are represented by contiguous pages on a floppy disk. If the user is creating and deleting a lot of files on a floppy, it is advisable to keep such a floppy less than 75 percent full.

**(FLOPPY.CAN.READP)** [Function]

Returns non-**NIL** if there is a floppy in the floppy drive.

Note: **FLOPPY.CAN.READP** does not provide any debouncing (protection against not fully closing the floppy drive door). It may be more useful to use **FLOPPY.WAIT.FOR.FLOPPY** (below).

**(FLOPPY.CAN.WRITEP)** [Function]

Returns non-**NIL** if there is a floppy in the floppy drive and the floppy drive can write on this floppy.

It is not possible to write on a floppy disk if the "write-protect notch" on the floppy disk is punched out.

**(FLOPPY.WAIT.FOR.FLOPPY** ***NEWFLG*****)** [Function]

If *NEWFLG* is **NIL**, waits until a floppy is in the floppy drive before returning.

If *NEWFLG* is **T**, waits until the existing floppy in the floppy drive, if any, is removed, then waits for a floppy to be inserted into the drive before returning.

**(FLOPPY.SCAVENGE)** [Function]

Attempts to repair a floppy whose critical records have become confused (causing errors when file operations are attempted). May also retrieve accidently-deleted files, provided they haven't been overwritten by new files.

**(FLOPPY.TO.FILE** ***TOFILE*****)** [Function]

Copies the entire contents of the floppy to the "floppy image" file *TOFILE*, which can be on a file server, local disk, etc. This can be used to create a centralized copy of a floppy, that different users can copy to their own floppy disks (using **FLOPPY.FROM.FILE**).

Note: A floppy image file for an 8-inch floppy is about 2500 pages long, regardless of the number of pages in use on the floppy.

**(FLOPPY.FROM.FILE** *FROMFILE***)** [Function]

Copies the "floppy image" file *FROMFILE* to the floppy. *FROMFILE* must be a file produced by **FLOPPY.TO.FILE**.

**(FLOPPY.ARCHIVE** *FILES NAME***)** [Function]

**FLOPPY.ARCHIVE** formats a floppy inserted into the floppy drive, giving the floppy the name *NAME*#1. **FLOPPY.ARCHIVE** then copies each file in *FILES* to the freshly formatted floppy. If the first floppy fills up, **FLOPPY.ARCHIVE** uses multiple floppies (named *NAME*#2, *NAME*#3, etc.), each time prompting the user to insert a new floppy.

The function **DIRECTORY** (page 24.33) is convenient for generating a list of files to archive. For example,

```
(FLOPPY.ARCHIVE
  (DIRECTORY '{ERIS}<Lisp>Project>*)
  'Project)
```

will archive all files on the directory **{ERIS}<Lisp>Project>** to floppies (named **Project#1**, **Project#2**, etc.).

**(FLOPPY.UNARCHIVE** *HOST/DIRECTORY***)** [Function]

**FLOPPY.UNARCHIVE** copies all files on the current floppy to the directory *HOST/DIRECTORY*. For example, **(FLOPPY.UNARCHIVE '{ERIS}<Lisp>Project>)** will copy each file on the current floppy to the directory **{ERIS}<Lisp>Project>**. If there is more than one floppy to restore from archive, **FLOPPY.UNARCHIVE** should be called on each floppy disk.

## 24.11 I/O Operations to and from Strings

It is possible to treat a string as if it were the contents of a file by using the following function:

**(OPENSTRINGSTREAM** *STR ACCESS***)** [Function]

Returns a stream that can be used to access the characters of the string *STR*. *ACCESS* may be either **INPUT**, **OUTPUT**, or **BOTH**; **NIL** defaults to **INPUT**. The stream returned may be used exactly like a file opened with the same access, except that output operations may not extend past the end of the original string. Also, string streams do not appear in the value of **(OPENP)**.

For example, after performing

**(SETQ STRM (OPENSTRINGSTREAM "THIS 2 (IS A LIST)"))**

the following succession of reads could occur:

```
(READ STRM)  => THIS
  (RATOM STRM)  => 2
  (READ STRM)  => (IS A LIST)
  (EOFP STRM)  => T
```

Compatibility Note: In Interlisp-10 it was possible to take input from a string simply by passing the string as the *FILE* argument to an input function. In order to maintain compatibility with this feature, Interlisp-D provides the same capability. This not terribly clean feature persists in the present implementation to give users time to convert old code. This means that strings are *not* equivalent to litatoms when specifying a file name as a stream argument (see page 24.13). In a future release, the old Interlisp-10 string-reading feature will be decommissioned, and **OPENSTRINGSTREAM** will be the only way to perform I/O on a string.

## 24.12 Temporary Files and the CORE Device

Many operating systems have a notion of "scratch file", a file typically used as temporary storage for data most naturally maintained in the form of a file, rather than some other data structure. A scratch file can be used as a normal file in most respects, but is automatically deleted from the file system after its useful life is up, e.g., when the job terminates, or the user logs out. In normal operation, the user need never explicitly delete such files, since they are guaranteed to disappear soon.

A similar functionality is provided in Interlisp-D by core-resident files. Core-resident files are on the device **CORE**. The directory structure for this device and all files on it are represented completely within the user's virtual memory. These files are treated as ordinary files by all file operations; their only distinguishing feature is that all trace of them disappears when the virtual memory is abandoned.

Core files are opened and closed by name the same as any other file, e.g., **(OPENSTREAM '{CORE}<FOO>FIE.DCOM 'OUTPUT)**. Directory names are completely optional, so files can also have names of the form **{CORE}NAME.EXT**. Core files can be enumerated by **DIRECTORY** (page 24.33). While open, they are registered in **(OPENP)**. They do consume virtual memory space, which is only reclaimed when the file is deleted. Some caution should thus be used when creating large **CORE** files. Since the virtual memory of an Interlisp-D workstation usually persists far longer than the typical process on a mainframe computer, it is still important to delete **CORE** files after they are no longer in use.

For many applications, the name of the scratch file is irrelevant, and there is no need for anyone to have access to the file independent of the program that created it. For such applications, **NODIRCORE** files are preferable. Files created on the device lisp **NODIRCORE** are core-resident files that have no name and are registered in no directory. These files "disappear", and the resources they consume are reclaimed, when all pointers to the file are dropped. Hence, such files need never be explicitly deleted or, for that matter, closed. The "name" of such a file is simply the stream object returned from **(OPENSTREAM '{NODIRCORE} 'OUTPUT)**, and it is this stream object that must be passed to all input/output operations, including **CLOSEF** and any calls to **OPENSTREAM** to reopen the file.

**(COREDEVICE** *NAME NODIRFLG***)** [Function]

Creates a new device for core-resident files and assigns *NAME* as its device name. Thus, after performing **(COREDEVICE 'FOO)**, one can execute **(OPENSTREAM '{FOO}BAR 'OUTPUT)** to open a file on that device. Interlisp-D is initialized with the single core-resident device named **CORE**, but **COREDEVICE** may be used to create any number of logically distinct core devices.

If *NODIRFLG* is non-**NIL**, a core device that acts like **{NODIRCORE}** is created.

Compatibility note: In Interlisp-10, it was possible to create scratch files by using file names with suffixes **;S** or **;T**. In Interlisp-D, these suffixes in file names are simply ignored when output is directed to a particular host or device. However, the function **PACKFILENAME.STRING** is defined to default the device name to **CORE** if the file has the **TEMPORARY** attribute and no explicit host is provided.

## 24.13 NULL Device

The **NULL** device provides a source of content-free "files". **(OPENSTREAM '{NULL} 'OUTPUT)** creates a stream that discards all output directed at it. **(OPENSTREAM '{NULL} 'INPUT)** creates a stream that is perpetually at end-of-file (i.e., has no input).

## 24.15 Deleting, Copying, and Renaming Files

**(DELFILE** *FILE***)** [Function]

Deletes *FILE* if possible. The file must be closed. Returns the full name of the file if deleted, else **NIL**. Recognition mode for *FILE* is **OLDEST**, i.e., if *FILE* does not have a version number specified, then **DELFILE** deletes the oldest version of the file.

**(COPYFILE** *FROMFILE TOFILE***)** [Function]

Copies *FROMFILE* to a new file named *TOFILE*. The source and destination may be on any combination of hosts/devices. **COPYFILE** attempts to preserve the **TYPE** and **CREATIONDATE** where possible. If the original file's file type is unknown, **COPYFILE** attempts to infer the type (file type is **BINARY** if any of its 8-bit bytes have their high bit on).

**COPYFILE** uses **COPYCHARS** (page 25.20) if the source and destination hosts have different **EOL** conventions. Thus, it is possible for the source and destination files to be of different lengths.

**(RENAMEFILE** *OLDFILE NEWFILE***)** [Function]

Renames *OLDFILE* to be *NEWFILE*. Causes an error, **FILE NOT FOUND** if *FILE* does not exist. Returns the full name of the new file, if successful, else **NIL** if the rename cannot be performed.

If *OLDFILE* and *NEWFILE* are on the same host/device, and the device implements a renaming primitive, **RENAMEFILE** can be very fast. However, if the device does not know how to rename files in place, or if *OLDFILE* and *NEWFILE* are on different devices, **RENAMEFILE** works by copying *OLDFILE* to *NEWFILE* and then deleting *OLDFILE*.

## 24.16 Searching File Directories

**DIRECTORIES** [Variable]

Global variable containing the list of directories searched (in order) by **SPELLFILE** and **FINDFILE** (below) when not given an explicit *DIRLST* argument. In this list, the atom **NIL** stands for the login directory (the value of **LOGINHOST/DIR**), and the atom **T** stands for the currently connected directory. Other elements should be *full* directory specifications, e.g., **{TWENTY}PS:<LISPUSERS>**, not merely **LISPUSERS**.

**LISPUSERSDIRECTORIES** [Variable]

Global variable containing a list of directories to search for "library" package files. Used by the **FILES** file package command (page 17.39).

**(SPELLFILE** *FILE NOPRINTFLG NSFLG DIRLST***)** [Function]

Searches for the file name *FILE*, possibly performing spelling correction (see page 20.15). Returns the corrected file name, if any, otherwise **NIL**.

If *FILE* has a directory field, **SPELLFILE** attempts spelling correction against the files in that particular directory. Otherwise, **SPELLFILE** searches for the file on the directory list *DIRLST* before attempting any spelling correction.

If *NOPRINTFLG* is **NIL**, **SPELLFILE** asks the user to confirm any spelling correction done, and prints out any files found, even if spelling correction is not done. If *NOPRINTFLG* = **T**, **SPELLFILE** does not do any printing, nor ask for approval.

If *NSFLG* = **T** (or **NOSPELLFLG** = **T**, see page 20.13), no spelling correction is attempted, though searching through *DIRLST* still occurs.

*DIRLST* is the list of directories searched if *FILE* does not have a directory field. If *DIRLST* is **NIL**, the value of the variable **DIRECTORIES** is used.

Note: If *DIRLST* is **NIL**, and *FILE* is not found by searching the directories on **DIRECTORIES**, but the root name of *FILE* has a **FILEDATES** property (page 17.20) indicating that a file by that name has been loaded, then the directory indicated in the **FILEDATES** property is searched, too. This additional search is not done if *DIRLST* is non-**NIL**.

**ERRORTYPELST** (page 14.22) initially contains the entry **((23 (SPELLFILE (CADR ERRORMESS) NIL NOFILESPELLFLG)))**, which causes **SPELLFILE** to be called in case of a **FILE NOT FOUND** error. If the variable **NOFILESPELLFLG** is **T** (its initial value), then spelling correction is not done on the file name, but **DIRECTORIES** is still searched. If **SPELLFILE** is successful, the operation will be reexecuted with the new (corrected) file name.

**(FINDFILE** *FILE NSFLG DIRLST***)** [Function]

Uses **SPELLFILE** to search for a file named *FILE*. If it finds one, returns its full name, with no user interaction. Specifically, it calls **(SPELLFILE** *FILE* **T** *NSFLG DIRLST***)**, after first performing two simple checks: If *FILE* has an explicit directory, it checks to see if a file so named exists, and if so returns that file. If *DIRLST* is **NIL**, it looks for *FILE* on the connected directory before calling **SPELLFILE**.

## 24.17 Listing File Directories

The function **DIRECTORY** allows the user to conveniently specify and/or program a variety of directory operations:

**(DIRECTORY** *FILES COMMANDS DEFAULTEXT DEFAULTVERS***)** [Function]

Returns, lists, or performs arbitrary operations on all files specified by the "file group" *FILES*. A file group has the form of a regular file name, except that the character * can be used to match any number of characters, including zero, in the file name. For example, the file group **A*B** matches all file names beginning with the character **A** and ending with the character **B**. The file group ***.DCOM** matches all files with an extension of **DCOM**.

If *FILES* does not contain an explicit extension, it is defaulted to *DEFAULTEXT*; if *FILES* does not contain an explicit version, it is defaulted to *DEFAULTVERS*. *DEFAULTEXT* and *DEFAULTVERS* themselves default to *. If the period or semicolon preceding the omitted extension or version, respectively, is present, the field is explicitly empty and no default is used. All other unspecified fields default to *. Null version is interpreted as "highest". Thus *FILES* = * or *.* or *.*;* enumerates all files on the connected directory; *FILES* = *. or *.;* enumerates all versions of files with null extension; *FILES* = *.; enumerates the highest version of files with null extension; and *FILES* = *.*; enumerates the highest version of all files. If *FILES* is **NIL**, it defaults to *.*;*.

Note: Some hosts/devices are not capable of supporting "highest version" in enumeration. Such hosts instead enumerate *all* versions.

For each file that matches the file group *FILES*, the "file commands" in *COMMANDS* are executed in order. Some of the file commands allow aborting the command processing for a given file, effectively filtering the list of files. The interpretation of the different file commands is described below. If *COMMANDS* is **NIL**, it defaults to **(COLLECT)**, which collects the matching file names in a list and returns it as the value of **DIRECTORY**.

The "file commands" in *COMMANDS* are interpreted as follows:

**P** Prints the file's name. For readability, **DIRECTORY** strips the directory from the name, printing it once as a header in front of each set of consecutive files on the same directory.

**PP** Prints the file's name without a version number.

a string Prints the string.

**READDATE, WRITEDATE**
**CREATIONDATE, SIZE**
**LENGTH, BYTESIZE**
**PROTECTION, AUTHOR**
**TYPE** Prints the appropriate information returned by **GETFILEINFO** (page 24.17).

**COLLECT** Adds the full name of this file to an accumulating list, which will be returned as the value of **DIRECTORY**.

**COUNTSIZE** Adds the size of this file to an accumulating sum, which will be returned as the value of **DIRECTORY**.

**DELETE** Deletes the file.

**DELVER** If this file is not the highest version of files by its name, delete it.

**PAUSE** Waits until the user types any char before proceeding with the rest of the commands (good for display if you want to ponder).

The following commands are predicates to filter the list. If the predicate is not satisfied, then processing for this file is aborted and no further commands (such as those above) are executed for this file.

Note: if the **P** and **PP** commands appear in *COMMANDS* ahead of any of the filtering commands below except **PROMPT**, they are postponed until after the filters. Thus, assuming the caller has placed the attribute options after the filters as well, no printing occurs for a file that is filtered out. This is principally so that functions like **DIR** (below) can both request printing and pass arbitrary commands through to **DIRECTORY**, and have the printing happen in the appropriate place.

**PROMPT** *MESS* Prompts with the yes/no question *MESS*; if user responds with **No**, abort command processing for this file.

**OLDERTHAN** *N* Continue command processing if the file hasn't been referenced (read or written) in *N* days. *N* can also be a string naming an explicit date and time since which the file must not have been referenced.

**NEWERTHAN** *N* Continue command processing if the file has been written within the last *N* days. *N* can also be a string naming an explicit date and time. Note that this is not quite the complement of **OLDERTHAN**, since it ignores the read date.

**BY** *USER* Continue command processing if the file was last written by the given user, i.e., its **AUTHOR** attribute matches (case insensitively) *USER*.

**@** *X* *X* is either a function of one argument (*FILENAME*), or an arbitrary expression which uses the variable **FILENAME** freely. If *X* returns **NIL**, abort command processing for this file.

The following two commands apply not to any particular file, but globally to the manner in which directory information is printed.

**OUT** *FILE* Directs output to *FILE*.

**COLUMNS** *N* Attempts to format output in *N* columns (rather than just 1).

**DIRECTORY** uses the variable **DIRCOMMANDS** as a spelling list to correct spelling and define abbreviations and synonyms (see page 20.15). Currently the following abbreviations are recognized:

| | | |
|---|---|---|
| **AU** | => | **AUTHOR** |
| **-** | => | **PAUSE** |
| **COLLECT?** | => | **PROMPT " ? " COLLECT** |
| **DA**<br>**DATE** | => | **CREATIONDATE** |
| **TI** | => | **WRITEDATE** |
| **DEL** | => | **DELETE** |
| **DEL?**<br>**DELETE?** | => | **PROMPT " delete? " DELETE** |
| **OLD** | => | **OLDERTHAN 90** |
| **PR** | => | **PROTECTION** |
| **SI** | => | **SIZE** |
| **VERBOSE** | => | **AUTHOR CREATIONDATE SIZE READDATE WRITEDATE** |

**(FILDIR** *FILEGROUP***)** [Function]

Obsolete synonym of **(DIRECTORY** *FILEGROUP***)**.

**(DIR** *FILEGROUP* $COM_1$ ... $COM_N$**)** [NLambda NoSpread Function]

Convenient form of **DIRECTORY** for use in type-in at the executive. Performs **(DIRECTORY** '*FILEGROUP* '**(P** $COM_1$ ... $COM_N$**))**.

**(NDIR** *FILEGROUP* $COM_1$ ... $COM_N$**)** [NLambda NoSpread Function]

Version of **DIR** that lists the file names in a multi-column format. Also, by default only lists the most recent version of files (unless *FILEGROUP* contains an explicit version).

## 24.18 File Servers

A file server is a shared resource on a local communications network which provides large amounts of file storage. Different file servers honor a variety of access protocols. Interlisp-D supports the following protocols: PUP-FTP, PUP-Leaf, and NS Filing. In addition, there are library packages available that support other communications protocols, such as TCP/IP and RS232.

With the exception of the RS232-based protocols, which exist only for file transfer, these network protocols are integrated into the Interlisp-D file system to allow files on a file server to be treated in much the same way files are accessed on local devices, such as the disk. Thus, it is possible to call **OPENSTREAM** on the file **{ERIS}<LISP>FOO.DCOM;3** and read from it or write to it just as if the file had been on the local disk (**{DSK}<LISP>FOO.DCOM;3**), rather than on a remote server named **ERIS**. However, the protocols vary in how much control they give the workstation over file system operations. Hence, some restrictions apply, as described in the following sections.

### 24.18.1 Pup File Server Protocols

There are two file server protocols in the family of Pup protocols: Leaf and FTP. Some servers support both, while others support only one of them. Interlisp-D uses whichever protocol is more appropriate for the requested operation.

Leaf is a random access protocol, so files opened using these protocols are **RANDACCESSP** (page 25.20), and thus most normal i/o operations can be performed. However, Leaf does not support directory enumeration. Hence, **DIRECTORY** cannot be used on a Leaf file server unless the server also supports FTP. In addition, Leaf does not supply easy access to a file's attributes. **INFILEP** and **GETFILEINFO** have to open the file for input in order to obtain their information, and hence the file's read date will change, even though the semantics of these functions do not imply it.

FTP is a file transfer protocol that only permits sequential access to files. However, most implementations of it are considerably more efficient than Leaf. Interlisp-D uses FTP in preference to Leaf whenever the call to **OPENSTREAM** requests sequential access only. In particular, the functions **SYSOUT** and **COPYFILE** open their files for sequential access. If a file server supports FTP but for some reason it is undesirable for Lisp to use it, one can set the internal variable **\FTPAVAILABLE** to **NIL**.

The system normally maintains a Leaf connection to a host in the background. This connection can be broken by calling

**(BREAKCONNECTION** *HOST***)**. Any subsequent reference to files on that host will reestablish the connection. The principal use for this function arises when the user interrupts a file operation in such a way that the file server thinks the file is open but Lisp thinks it is closed (or not yet open). As a result, the next time Lisp tries to open the file, it gets a file busy error.

## 24.18.2 Xerox NS File Server Protocols

Interlisp supports file access to Xerox 803x file servers, using the Filing Protocol built on Xerox Network Systems protocols. Interlisp-D determines that a host is an NS File Server by the presence of a colon in its name, e.g., **{PHYLEX:}**. The general format of NS fileserver device names is **{***SERVERNAME*:*DOMAIN*:*ORGANIZATION***}**; the device specification for an 8000-series product in general includes the ClearingHouse domain and organization. If domain and organization are not supplied directly, then they are obtained from the defaults, which themselves are found by consulting the nearest ClearingHouse if the user has not defined them in an init file (page 31.8). However, note that the server name must still have a colon in it to distinguish it from other types of host names (e.g., Pup server names).

NS file servers in general permit arbitrary characters in file names. The user should be cognizant of file name quoting conventions (page 24.6), and the fact that any file name presented as a litatom needs to have characters of significance to the reader, such as space, escaped with a **%**. Of course, one can always present the file name as a string, in which case only the quoting conventions are important.

NS file servers support a true hierarchical file system, where subdirectories are just another kind of file, which needs to be explicitly created. In Interlisp, subdirectories are created automatically as needed: A call to **OPENFILE** to create a file in a non-existent subdirectory automatically creates the subdirectory; **CONN** to a non-existent subdirectory asks the user whether to create the directory. For those using Star software, a directory corresponds to a "File Drawer", while a subdirectory corresponds to a "File Folder".

Because of their hierarchical structure, NS directories can be enumerated to arbitrary levels. The default is to enumerate all the files (the leaves of the tree), omitting the subdirectory nodes themselves. This default can be changed by the following variable:

**FILING.ENUMERATION.DEPTH** [Variable]

This variable is either a number, specifying the number of levels deep to enumerate, or **T**, meaning enumerate to all levels. In the former case, when the enumeration reaches the specified depth, only the subdirectory name rooted at that level is listed, and none of its descendants is listed. When **FILING.ENUMERATION.DEPTH** is **T**, all files are listed, and no subdirectory names are listed. **FILING.ENUMERATION.DEPTH** is initially **T**.

Independent of **FILING.ENUMERATION.DEPTH**, a request to enumerate the top-level of a file server's hierarchy lists only the top level, i.e., assumes a depth of 1. For example, **(DIRECTORY '{PHYLEX:})** lists exactly the top-level directories of the server **PHYLEX:**.

NS file servers do not currently support random access. Therefore, **SETFILEPTR** of an NS file generally causes an error. However, **GETFILEPTR** returns the correct character position for open files on NS file servers. In addition, **SETFILEPTR** works in the special case where the file is open for input, and the file pointer is being set forward. In this case, the intervening characters are automatically read.

Even while Interlisp has no file open on an NS Server, the system maintains a "session" with the server for a while in order to improve the speed of subsequent requests to the server. While this session is open, it is possible for some nodes of the server's file system to appear "busy" or inaccessible to certain clients on other workstations (such as Star). If this happens, the following function can be used to terminate any open sessions immediately:

**(BREAK.NSFILING.CONNECTION** ***HOST*****)** [Function]

Closes any open connections to NS file server *HOST*.

## 24.18.3 Operating System Designations

Some of the network server protocols are implemented on more than one kind of foreign host. Such hosts vary in their conventions for logging in, naming files, representing end-of-line, etc. In order for Interlisp to communicate gracefully with all these hosts, it is necessary that the variable **NETWORKOSTYPES** be correctly set.

**NETWORKOSTYPES** [Variable]

An association-list that associates a host name with its operating system type. Elements in this list are of the form (*HOSTNAME* .

*TYPE*), for example, **(MAXC2 . TENEX)**. The operating system types currently known to Lisp are **TENEX**, **TOPS20**, **UNIX**, and **VMS**. The host names in this list should be the "canonical" host name, represented as an uppercase atom. For Pup and NS hosts, the function **CANONICAL.HOSTNAME** (below) can be used to determine which of several aliases of a server is the canonical name.

**(CANONICAL.HOSTNAME** *HOSTNAME***)** [Function]

Returns the "canonical" name of the server *HOSTNAME*, or **NIL** if *HOSTNAME* is not the name of a server.

## 24.18.4 Logging In

Most file servers require a user name and password for access. Interlisp-D maintains an ephemeral database of user names and passwords for each host accessed recently. The database vanishes when **LOGOUT**, **SAVEVM**, **SYSOUT**, or **MAKESYS** is executed, so that the passwords remain secure from any subsequent user of the same virtual memory image. Interlisp-D also maintains a notion of the "default" user name and password, which are generally those with which the user initially logs in (on the 1132, the default user name corresponds to that displayed in the Alto executive).

When a file server for which the system does not yet have an entry in its password database requests a name and password, the system first tries the default user name and password. If the file server doesn't recognize that name/password, the system prompts the user for a name and password to use for that host. It suggests a default name:

**{ERIS} Login: Green**

which the user can accept by typing a carriage return, or replace the name by typing a new name or backspacing over it. Following the name, the user is prompted for a password:

**{ERIS} Login: Verdi (password)**

which is not echoed, terminated by another carriage return. This information is stored in the password database so that the user is prompted only once, until the database is again cleared.

Interlisp-D also prompts for password information when a protection violation occurs on accessing a directory on certain kinds of servers that support password-protected directories. Some such servers allow one to protect a file in a way that it is inaccessible to even its owner until the file's protection is changed; in such case, no password would help, and the system causes the normal **PROTECTION VIOLATION** error.

The user can abort a password interaction by typing the **ERROR** interrupt, initially Control-E. This generally either causes a **PROTECTION VIOLATION** error, if the password was requested in order to gain access to a protected file on an otherwise accessible server; or to act as though the server did not exist, in the case where the password was needed in order to gain *any* access to the server.

The following functions are useful for altering the password database:

**(LOGIN** *HOSTNAME FLG DIRECTORY MSG***)** [Function]

Forces Interlisp-D to ask for the user name and password to be used when accessing host *HOSTNAME*. Any previous login information for *HOSTNAME* is overriden. If *HOSTNAME* is **NIL**, it overrides login information for all hosts and resets the default user name and password to be those typed in by the user. The special value *HOSTNAME* = **NS::** is used to obtain the default user name and password for all logins for NS Servers.

If *FLG* is the atom **QUIET**, only prompts the user if there is no cached information for *HOSTNAME*.

If *DIRECTORY* is specified, it is the name of a directory on *HOSTNAME*. In this case, the information requested is the "connect" password for that directory. Connect passwords for any number of different directories on a host can be maintained.

If *MSG* is non-**NIL**, it is a message (a string) to be printed before the name and password information is requested.

**LOGIN** returns the user name with which the user completed the login.

**(SETPASSWORD** *HOST USER PASSWORD DIRECTORY***)** [Function]

Sets the values in the internal password database, exactly as if the strings *USER* and *PASSWORD* were typed in via **(LOGIN** *HOST* **NIL** *DIRECTORY***)**.

**(SETUSERNAME** *NAME***)** [Function]

Sets the default user name to *NAME*.

**(USERNAME** *FLG STRPTR PRESERVECASE***)** [Function]

If *FLG* = **NIL**, returns the default user name. This is the only value of *FLG* that is meaningful in Interlisp-D.

**USERNAME** returns the value as a string, unless *STRPTR* is **T**, in which case **USERNAME** returns the value as an atom. The name is returned in upper case, unless *PRESERVECASE* is true.

## 24.18.5 Abnormal Conditions

If Interlisp-D tries to access a file and does not get a response from the file server in a reasonable period of time, it prints a message that the file server is not responding, and keeps trying. If the file server has actually crashed, this may continue indefinitely. A control-E or similar interrupt aborts out of this state.

If the file server crashes but is restarted before the user attempts to do anything, file operations will usually proceed normally, except for a brief pause while Interlisp-D tries to reestablish any connections it had open before the crash. However, this is not always possible. For example, when a file is open for sequential output and the server crashes, there is no way to recover the output already written, since it vanished with the crash. In such cases, the system will cause an error such as **Connection Lost**.

**LOGOUT** closes any file server connections that are currently open. On return, it attempts to reestablish connections for any files that were open before logging out. If a file has disappeared or been modified, Interlisp-D reports this fact. Files that were open for sequential access generally cannot be reopened after **LOGOUT**.

Interlisp supports simultaneous access to the same server from different processes and permits overlapping of Lisp computation with file server operations, allowing for improved performance. However, as a corollary of this, a file is not closed the instant that **CLOSEF** returns; Interlisp closes the file "in the background". It is therefore very important that the user exits Interlisp via **(LOGOUT)**, or **(LOGOUT T)**, rather than boot the machine.

On rare occasions, the Ethernet may appear completely unresponsive, due to Interlisp having gotten into a bad state. Typing **(RESTART.ETHER)** will reinitialize Lisp's Ethernet driver(s), just as when the Lisp system is started up following a **LOGOUT**, **SYSOUT**, etc (see page 31.38)

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# 25. INPUT/OUTPUT FUNCTIONS

This chapter describes the standard I/O functions used for reading and printing characters and Interlisp expressions on files and other streams. First, the primitive input functions are presented, then the output functions, then functions for random-access operations (such as searching a file for a given stream, or changing the "next-character" pointer to a position in a file). Next, the **PRINTOUT** statement is documented (page 25.23), which provides an easy way to write complex output operations. Finally, read tables, used to parse characters as Interlisp expressions, are documented.

## 25.1 Specifying Streams for Input/Output Functions

Most of the input/output functions in Interlisp-D have an argument named *STREAM* or *FILE*, specifying on which open stream the function's action should occur (the name *FILE* is used in older functions that predate the concept of stream; the two should, however, be treated synonymously). The value of this argument should be one of the following:

a stream — An object of type **STREAM**, as returned by **OPENSTREAM** (page 24.2) or other stream-producing functions, is always the most precise and efficient way to designate a stream argument.

**T**

The litatom **T** designates the terminal input or output stream of the currently running process, controlling input from the keyboard and output to the display screen. For functions where the direction (input or output) is ambiguous, **T** is taken to designate the terminal output stream. The **T** streams are always open; they cannot be closed.

The terminal output stream can be set to a given window or display stream by using **TTYDISPLAYSTREAM** (page 28.29). The terminal input stream cannot be changed. For more information on terminal I/O, see page 30.1.

**NIL**

The litatom **NIL** designates the "primary" input or output stream. These streams are initially the same as the terminal input/output streams, but they can be changed by using the functions **INPUT** (page 25.3) and **OUTPUT** (page 25.8).

For functions where the direction (input or output) is ambiguous, e.g., **GETFILEPTR**, the argument **NIL** is taken to mean the primary input stream, if that stream is not identical to the terminal input stream, else the primary output stream.

a window — Uses the display stream of the window (page 28.34). Valid for output only.

a file name — As of this writing, the name of an open file (as a litatom) can be used as a stream argument. However, there are inefficiencies and possible future incompatibilities associated with doing so. See page page 24.13 for details.

**(GETSTREAM** ***FILE ACCESS*****)** [Function]

Coerces the argument *FILE* to a stream by the above rules. If *ACCESS* is **INPUT**, **OUTPUT**, or **BOTH**, produces the stream designated by *FILE* that is open for *ACCESS*. If *ACCESS* = **NIL**, returns a stream for *FILE* open for any kind of input/output (see the list above for the ambiguous cases). If *FILE* does not designate a stream open in the specified mode, causes an error, **FILE NOT OPEN**.

**(STREAMP** ***X*****)** [Function]

Returns *X* if *X* is a **STREAM**, otherwise **NIL**.

## 25.2 Input Functions

While the functions described below can take input from any stream, some special actions occur when the input is from the terminal (the **T** input stream, see page 25.1). When reading from the terminal, the input is buffered a line at a time, unless buffering has been inhibited by **CONTROL** (page 30.10) or the input is being read by **READC** or **PEEKC** (page 25.5). Using specified editing characters, the user can erase a character at a time, a word at a time, or the whole line. The keys that perform these editing functions are assignable via **SETSYNTAX** (page 25.37), with the initial settings chosen to be those most natural for the given operating system. In Interlisp-D, the initial settings are as follows: characters are deleted one at a time by Backspace; words are erased by control-W; the whole line is erased by control-Q.

On the Interlisp-D display, deleting a character or a line causes the characters to be physically erased from the screen. In

Interlisp-10, the deleting action can be modified for various types of display terminals by using **DELETECONTROL** (page 30.8).

Unless otherwise indicated, when the end of file is encountered while reading from a file, all input functions generate an error, **END OF FILE**. Note that this does not close the input file. The **ENDOFSTREAMOP** stream attribute (page 24.19) is useful for changing the behavior at end of file.

Most input functions have a *RDTBL* argument, which specifies the read table to be used for input (see page 25.33). Unless otherwise specified, if *RDTBL* is **NIL**, the primary read table is used.

If the *FILE* or *STREAM* argument to an input function is **NIL**, the primary input stream is used (see page 25.1).

**(INPUT *FILE*)** [Function]

Sets *FILE* as the primary input stream; returns the old primary input stream. *FILE* must be open for input.

**(INPUT)** returns the current primary input stream, which is not changed.

Note: If the primary input stream is set to a file, the file's full name, rather than the stream itself, is returned. See discussion on page 24.13.

**(READ *FILE RDTBL FLG*)** [Function]

Reads one expression from *FILE*. Atoms are delimited by the break and separator characters as defined in *RDTBL*. To include a break or separator character in an atom, the character must be preceded by the character **%**, e.g., **AB%(C** is the atom **AB(C**, **%%** is the atom **%**, **%*control-K*** is the atom control-K. For input from the terminal, an atom containing an interrupt character can be input by typing instead the corresponding alphabetic character preceded by control-V, e.g., **↑VD** for control-D.

Strings are delimited by double quotes. To input a string containing a double quote or a %, precede it by %, e.g., **"AB%"C"** is the string **AB"C**. Note that % can always be typed even if next character is not "special", e.g., **%A%B%C** is read as **ABC**.

If an atom is interpretable as a number, **READ** creates a number, e.g., **1E3** reads as a floating point number, **1D3** as a literal atom, **1.0** as a number, **1,0** as a literal atom, etc. An integer can be input in a non-decimal radix by using syntax such as **123Q**, **|b10101**, **|5r1234** (see page 7.4). The function **RADIX** (page 25.13), sets the radix used to print integers.

When reading from the terminal, all input is line-buffered to enable the action of the backspacing control characters, unless inhibited by **CONTROL** (page 30.10). Thus no characters are actually seen by the program until a carriage-return (actually the character with terminal syntax class **EOL**, see page 30.6), is typed. However, for reading by **READ**, when a matching right parenthesis is encountered, the effect is the same as though a carriage-return were typed, i.e., the characters are transmitted. To indicate this, Interlisp also prints a carriage-return line-feed on the terminal. The line buffer is also transmitted to **READ** whenever an **IMMEDIATE** read macro character is typed (page 25.41).

*FLG* = **T** suppresses the carriage-return normally typed by **READ** following a matching right parenthesis. (However, the characters are still given to **READ**; i.e., the user does not have to type the carriage-return.)

**(RATOM** *FILE RDTBL***)** [Function]

Reads in one atom from *FILE*. Separation of atoms is defined by *RDTBL*. **%** is also defined for **RATOM**, and the remarks concerning line-buffering and editing control characters also apply.

If the characters comprising the atom would normally be interpreted as a number by **READ**, that number is returned by **RATOM**. Note however that **RATOM** takes no special action for " whether or not it is a break character, i.e., **RATOM** never makes a string.

**(RSTRING** *FILE RDTBL***)** [Function]

Reads characters from *FILE* up to, but not including, the next break or separator character, and returns them as a string. Backspace, control-W, control-Q, control-V, and **%** have the same effect as with **READ**.

Note that the break or separator character that terminates a call to **RATOM** or **RSTRING** is *not* read by that call, but remains in the buffer to become the first character seen by the next reading function that is called. If that function is **RSTRING**, it will return the null string. This is a common source of program bugs.

**(RATOMS** *A FILE RDTBL***)** [Function]

Calls **RATOM** repeatedly until the atom *A* is read. Returns a list of the atoms read, not including *A*.

**(RATEST** *FLG***)** [Function]

If *FLG* = **T**, **RATEST** returns **T** if a separator was encountered immediately prior to the atom returned by the last **RATOM** or **READ**, **NIL** otherwise.

If *FLG* = **NIL**, **RATEST** returns **T** if last atom read by **RATOM** or **READ** was a break character, **NIL** otherwise.

If *FLG* = **1**, **RATEST** returns **T** if last atom read (by **READ** or **RATOM**) contained a **%** used to quote the next character (as in **%[** or **%A%B%C**), **NIL** otherwise.

**(READC** *FILE RDTBL***)** [Function]

Reads and returns the next character, including %, ", etc, i.e., is not affected by break or separator characters. The action of **READC** is subject to line-buffering, i.e., **READC** does not return a value until the line has been terminated even if a character has been typed. Thus, the editing control characters have their usual effect. *RDTBL* does not directly affect the value returned, but is used as usual in line-buffering, e.g., determining when input has been terminated. If **(CONTROL T)** has been executed (page 30.10), defeating line-buffering, the *RDTBL* argument is irrelevant, and **READC** returns a value as soon as a character is typed (even if the character typed is one of the editing characters, which ordinarily would never be seen in the input buffer).

**(PEEKC** *FILE* —**)** [Function]

Returns the next character, but does not actually read it and remove it from the buffer. If reading from the terminal, the character is echoed as soon as **PEEKC** reads it, even though it is then "put back" into the system buffer, where backspace, control-W, etc. could change it. Thus it is possible for the value returned by **PEEKC** to "disagree" in the first character with a subsequent **READ**.

**(LASTC** *FILE***)** [Function]

Returns the last character read from *FILE*.

**(READCCODE** *FILE RDTBL***)** [Function]

Returns the next character *code* from *STREAM*; thus, this operation is equivalent to, but more efficient than, **(CHCON1 (READC** *FILE RDTBL***))**.

**(PEEKCCODE** *FILE* —**)** [Function]

Returns, without consuming, the next character *code* from *STREAM*; thus, this operation is equivalent to, but more efficient than, **(CHCON1 (PEEKC** *FILE***))**.

**(BIN** *STREAM***)** [Function]

Returns the next byte from *STREAM*. This operation is useful for reading streams of binary, rather than character, data.

Note: **BIN** is similar to **READCCODE**, except that **BIN** always reads a single byte, whereas **READCCODE** reads a "character" that can consist of more than one byte, depending on the character and its encoding (see page 25.22).

**READ, RATOM, RATOMS, PEEKC, READC** all wait for input if there is none. The only way to test whether or not there is input is to use **READP**:

**(READP** *FILE FLG***)** [Function]

Returns **T** if there is anything in the input buffer of *FILE*, **NIL** otherwise. This operation is only interesting for streams whose source of data is dynamic, e.g., the terminal or a byte stream over a network; for other streams, such as to files, **(READP** *FILE***)** is equivalent to **(NOT (EOFP** *FILE***))**.

Note that because of line-buffering, **READP** may return **T**, indicating there is input in the buffer, but **READ** may still have to wait.

Frequently, the terminal's input buffer contains a single **EOL** character left over from a previous input. For most applications, this situation wants to be treated as though the buffer were empty, and so **READP** returns **NIL** in this case. However, if *FLG* = **T**, **READP** returns **T** if there is *any* character in the input buffer, including a single **EOL**. *FLG* is ignored for streams other than the terminal.

**(EOFP** *FILE***)** [Function]

Returns true if *FILE* is at "end of file", i.e., the next call to an input function would cause an **END OF FILE** error; **NIL** otherwise. For randomly accessible files (page 25.18), this can also be thought of as the file pointer pointing beyond the last byte of the file. *FILE* must be open for (at least) input, or an error is generated, **FILE NOT OPEN**.

Note that **EOFP** can return **NIL** and yet the next call to **READ** might still cause an **END OF FILE** error, because the only characters remaining in the input were separators or otherwise constituted an incomplete expression. The function **SKIPSEPRS** (page 25.7) is sometimes more useful as a way of detecting end of file when it is known that all the expressions in the file are well formed.

**(WAITFORINPUT** *FILE***)** [Function]

Waits until input is available from *FILE* or from the terminal, i.e. from **T**. **WAITFORINPUT** is functionally equivalent to (until **(OR (READP T) (READP FILE)) do NIL)**, except that it does not use up machine cycles while waiting. Returns the device for which input is now available, i.e. *FILE* or **T**.

*FILE* can also be an integer, in which case **WAITFORINPUT** waits until there is input available from the terminal, or until *FILE* milliseconds have elapsed. Value is **T** if input is now available, **NIL** in the case that **WAITFORINPUT** timed out.

**(SKREAD** *FILE REREADSTRING RDTBL***)** [Function]

"Skip Read". **SKREAD** consumes characters from *FILE* as if one call to **READ** had been performed, without paying the storage and compute cost to really read in the structure. *REREADSTRING* is for the case where the caller has already performed some **READC**'s and **RATOM**'s before deciding to skip this expression. In this case, *REREADSTRING* should be the material already read (as a string), and **SKREAD** operates as though it had seen that material first, thus setting up its parenthesis count, double-quote count, etc.

The read table *RDTBL* is used for reading from *FILE*. If *RDTBL* is **NIL**, it defaults to the value of **FILERDTBL**. **SKREAD** may have difficulties if unusual read macros (page 25.39) are defined in *RDTBL*. **SKREAD** does not recognize read macro characters in *REREADSTRING*, nor **SPLICE** or **INFIX** read macros. This is only a problem if the read macros are defined to parse subsequent input in the stream that does not follow the normal parenthesis and string-quote conventions.

**SKREAD** returns **%)** if the read terminated on an unbalanced closing parenthesis; **%]** if the read terminated on an unbalanced **%]**, i.e., one which also would have closed any extant open left parentheses; otherwise **NIL**.

**(SKIPSEPRS** *FILE RDTBL***)** [Function]

Consumes characters from *FILE* until it encounters a non-separator character (as defined by *RDTBL*). **SKIPSEPRS** returns, but does not consume, the terminating character, so that the next call to **READC** would return the same character. If no non-separator character is found before the end of file is reached, **SKIPSEPRS** returns **NIL** and leaves the stream at end of file. This function is useful for skipping over "white space" when scanning a stream character by character, or for detecting end of file when reading expressions from a stream with no pre-arranged terminating expression.

## 25.3 Output Functions

Unless otherwise specified by **DEFPRINT** (page 25.16), pointers other than lists, strings, atoms, or numbers, are printed in the form {*DATATYPE*} followed by the octal representation of the address of the pointer (regardless of radix). For example, an array pointer might print as **{ARRAYP}#43,2760**. This printed representation is for compactness of display on the user's terminal, and will *not* read back in correctly; if the form above is read, it will produce the litatom **{ARRAYP}#43,2760**.

Note: the term "end-of-line" appearing in the description of an output function means the character or characters used to terminate a line in the file system being used by the given implementation of Interlisp. For example, in Interlisp-D end-of-line is indicated by the character carriage-return.

Some of the functions described below have a *RDTBL* argument, which specifies the read table to be used for output (see page 25.33). If *RDTBL* is **NIL**, the primary read table is used.

Most of the functions described below have an argument *FILE*, which specifies the stream on which the operation is to take place. If *FILE* is **NIL**, the primary output stream is used (see page 25.1).

**(OUTPUT *FILE*)** [Function]

Sets *FILE* as the primary output stream; returns the old primary output stream. *FILE* must be open for output.

**(OUTPUT)** returns the current primary output stream, which is not changed.

Note: If the primary output stream is set to a file, the file's full name, rather than the stream itself, is returned. See discussion on page 24.13.

**(PRIN1 *X FILE*)** [Function]

Prints *X* on *FILE*.

**(PRIN2 *X FILE RDTBL*)** [Function]

Prints *X* on *FILE* with %'s and "'s inserted where required for it to read back in properly by **READ**, using *RDTBL*.

Both **PRIN1** and **PRIN2** print any kind of Lisp expression, including lists, atoms, numbers, and strings. **PRIN1** is generally used for printing expressions where human readability, rather than machine readability, is important, e.g., when printing text rather than program fragments. **PRIN1** does not print double quotes around strings, or % in front of special characters. **PRIN2** is used for printing Interlisp expressions which can then be read back into Interlisp with **READ**; i.e., break and separator characters in atoms will be preceded by %'s. For example, the atom "**()**" is printed as **%(%)** by **PRIN2**. If the integer output radix (as set by **RADIX**, page 25.13) is not 10, **PRIN2** prints the integer using the input syntax for non-decimal integers (see page 7.4) but **PRIN1** does not (but both print the integer in the output radix).

**(PRIN3** *X FILE***)** [Function]

**(PRIN4** *X FILE RDTBL***)** [Function]

**PRIN3** and **PRIN4** are the same as **PRIN1** and **PRIN2** respectively, except that they do not increment the horizontal position counter nor perform any linelength checks. They are useful primarily for printing control characters.

**(PRINT** *X FILE RDTBL***)** [Function]

Prints the expression *X* using **PRIN2** followed by an end-of-line. Returns *X*.

**(PRINTCCODE** *CHARCODE FILE***)** [Function]

Outputs a single character whose code is *CHARCODE* to *FILE*. This is similar to **(PRIN1 (CHARACTER** *CHARCODE***))**, except that numeric characters are guaranteed to print "correctly"; e.g., **(PRINTCCODE (CHARCODE 9))** always prints "**9**", independent of the setting of **RADIX**.

Note that **PRINTCCODE** may actually print more than one byte on *FILE*, due to character encoding and end of line conventions; thus, no assumptions should be made about the relative motion of the file pointer (see **GETFILEPTR**, page 25.19) during this operation.

**(BOUT** *STREAM BYTE***)** [Function]

Outputs a single 8-bit byte to *STREAM*. This is similar to **PRINTCCODE**, but for binary streams the character position in *STREAM* is not updated (as with **PRIN3**), and end of line conventions are ignored.

Note: **BOUT** is similar to **PRINTCCODE**, except that **BOUT** always writes a single byte, whereas **PRINTCCODE** writes a "character" that can consist of more than one byte, depending on the character and its encoding (see page 25.22).

**(SPACES** *N FILE***)** [Function]

Prints *N* spaces. Returns **NIL**.

**(TERPRI** *FILE***)** [Function]

Prints an end-of-line character. Returns **NIL**.

**(FRESHLINE *STREAM*)** [Function]

Equivalent to **TERPRI**, except it does nothing if it is already at the beginning of the line. Returns **T** if it prints an end-of-line, **NIL** otherwise.

**(TAB *POS MINSPACES FILE*)** [Function]

Prints the appropriate number of spaces to move to position *POS*. *MINSPACES* indicates how many spaces must be printed (if **NIL**, 1 is used). If the current position plus *MINSPACES* is greater than *POS*, **TAB** does a **TERPRI** and then **(SPACES *POS*)**. If *MINSPACES* is **T**, and the current position is greater than *POS*, then **TAB** does nothing.

Note: A sequence of **PRINT**, **PRIN2**, **SPACES**, and **TERPRI** expressions can often be more conveniently coded with a single **PRINTOUT** statement (page 25.23).

**(SHOWPRIN2 *X FILE RDTBL*)** [Function]

Like **PRIN2** except if **SYSPRETTYFLG = T**, prettyprints *X* instead. Returns *X*.

**(SHOWPRINT *X FILE RDTBL*)** [Function]

Like **PRINT** except if **SYSPRETTYFLG = T**, prettyprints *X* instead, followed by an end-of-line. Returns *X*.

**SHOWPRINT** and **SHOWPRIN2** are used by the programmer's assistant (page 13.1) for printing the values of expressions and for printing the history list, by various commands of the break package (page 14.1), e.g. **?=** and **BT** commands, and various other system packages. The idea is that by simply settting or binding **SYSPRETTYFLG** to **T** (initially **NIL**), the user instructs the system when interacting with the user to **PRETTYPRINT** expressions (page 26.40) instead of printing them.

**(PRINTBELLS —)** [Function]

Used by DWIM (page 20.1) to print a sequence of bells to alert the user to stop typing. Can be advised or redefined for special applications, e.g., to flash the screen on a display terminal.

**(FORCEOUTPUT *STREAM WAITFORFINISH*)** [Function]

Forces any buffered output data in *STREAM* to be transmitted.

If *WAITFORFINISH* is non-**NIL**, this doesn't return until the data has been forced out.

**(POSITION *FILE N*)** [Function]

Returns the column number at which the next character will be read or printed. After a end of line, the column number is 0. If *N* is non-**NIL**, *resets* the column number to be *N*.

Note that resetting **POSITION** only changes Lisp's belief about the current column number; it does not cause any horizontal motion. Also note that **(POSITION** *FILE***)** is *not* the same as **(GETFILEPTR** *FILE***)** which gives the position in the *file*, not on the *line*.

**(LINELENGTH *N FILE*)** [Function]

Sets the length of the print line for the output file *FILE* to *N*; returns the former setting of the line length. *FILE* defaults to the primary output stream. **(LINELENGTH NIL** *FILE***)** returns the current setting for *FILE*. When a file is first opened, its line length is set to the value of the variable **FILELINELENGTH**.

Whenever printing an atom or string would increase a file's position *beyond* the line length of the file, an end of line is automatically inserted first. This action can be defeated by using **PRIN3** and **PRIN4** (page 25.9).

**(SETLINELENGTH *N*)** [Function]

Sets the line length for the terminal by doing **(LINELENGTH** *N* **T)**. If *N* is **NIL**, it determines *N* by consulting the operating system's belief about the terminal's characteristics. In Interlisp-D, this is a no-op.

## 25.3.1 PRINTLEVEL

When using Interlisp one often has to handle large, complicated lists, which are difficult to understand when printed out. **PRINTLEVEL** allows the user to specify in how much detail lists should be printed. The print functions **PRINT**, **PRIN1**, and **PRIN2** are all affected by level parameters set by:

**(PRINTLEVEL *CARVAL CDRVAL*)** [Function]

Sets the **CAR** print level to *CARVAL*, and the **CDR** print level to *CDRVAL*. Returns a list cell whose **CAR** and **CDR** are the old settings. **PRINTLEVEL** is initialized with the value **(1000 . -1)**.

In order that **PRINTLEVEL** can be used with **RESETFORM** or **RESETSAVE**, if *CARVAL* is a list cell it is equivalent to **(PRINTLEVEL (CAR** *CARVAL***) (CDR** *CARVAL***))**.

**(PRINTLEVEL *N* NIL)** changes the **CAR** printlevel without affecting the **CDR** printlevel. **(PRINTLEVEL NIL *N*)** changes the **CDR**

printlevel with affecting the **CAR** printlevel. **(PRINTLEVEL)** gives the current setting without changing either.

Note: control-P (page 30.2) can be used to change the **PRINTLEVEL** setting dynamically, even while Interlisp is printing.

The **CAR** printlevel specifies how "deep" to print a list. Specifically, it is the number of unpaired left parentheses which will be printed. Below that level, all lists will be printed as **&**. If the **CAR** printlevel is *negative*, the action is similar except that an end-of-line is inserted after each right parentheses that would be immediately followed by a left parenthesis.

The **CDR** printlevel specifies how "long" to print a list. It is the number of top level list elements that will be printed before the printing is terminated with **--**. For example, if *CDRVAL* = 2, **(A B C D E)** will print as **(A B --)**. For sublists, the number of list elements printed is also affected by the depth of printing in the **CAR** direction: Whenever the *sum* of the depth of the sublist (i.e. the number of unmatched left parentheses) and the number of elements is greater than the **CDR** printlevel, **--** is printed. This gives a "triangular" effect in that less is printed the farther one goes in either **CAR** or **CDR** direction. If the **CDR** printlevel is negative, then it is the same as if the **CDR** printlevel were infinite.

Examples:

| | |
|---|---|
| After: | **(A (B C (D (E F) G) H) K L)** prints as: |
| **(PRINTLEVEL 3 -1)** | **(A (B C (D & G) H) K L)** |
| **(PRINTLEVEL 2 -1)** | **(A (B C & H) K L)** |
| **(PRINTLEVEL 1 -1)** | **(A & K L)** |
| **(PRINTLEVEL 0 -1)** | **&** |
| **(PRINTLEVEL 1000 2)** | **(A (B --) --)** |
| **(PRINTLEVEL 1000 3)** | **(A (B C --) K --)** |
| **(PRINTLEVEL 1 3)** | **(A & K --)** |

**PLVLFILEFLG** [Variable]

Normally, **PRINTLEVEL** only affects terminal output. Output to all other files acts as though the print level is infinite. However, if **PLVLFILEFLG** is **T** (initially **NIL**), then **PRINTLEVEL** affects output to files as well.

The following three functions are useful for printing isolated expressions at a specified print level without going to the overhead of resetting the global print level.

**(LVLPRINT** *X FILE CARLVL CDRLVL TAIL***)** [Function]

Performs **PRINT** of *X* to *FILE*, using as **CAR** and **CDR** print levels the values *CARLVL* and *CDRLVL*, respectively. Uses the **T** read table. If *TAIL* is specified, and *X* is a tail of it, then begins its printing with "...", rather than on open parenthesis.

**(LVLPRIN2** *X FILE CARLVL CDRLVL TAIL***)** [Function]

Similar to **LVLPRIN2**, but performs a **PRIN2**.

**(LVLPRIN1** *X FILE CARLVL CDRLVL TAIL***)** [Function]

Similar to **LVLPRIN1**, but performs a **PRIN1**.

## 25.3.2 Printing numbers

How the ordinary printing functions (**PRIN1**, **PRIN2**, etc.) print numbers can be affected in several ways. **RADIX** influences the printing of integers, and **FLTFMT** influences the printing of floating point numbers. The setting of the variable **PRXFLG** determines how the symbol-manipulation functions handle numbers. The **PRINTNUM** package permits greater controls on the printed appearance of numbers, allowing such things as left-justification, suppression of trailing decimals, etc.

**(RADIX** *N***)** [Function]

Resets the output radix for integers to the absolute value of *N*. The value of **RADIX** is its previous setting. **(RADIX)** gives the current setting without changing it. The initial setting is 10.

Note that **RADIX** affects output *only*. There is no input radix; on input, numbers are interpreted as decimal unless they are entered in a non-decimal radix with syntax such as **123Q**, **|b10101**, **|5r1234** (see page 7.4). **RADIX** does not affect the behavior of **UNPACK**, etc., unless the value of **PRXFLG** (below) is **T**. For example, if **PRXFLG** is **NIL** and the radix is set to 8 with **(RADIX 8)**, the value of **(UNPACK 9)** is **(9)**, not **(1 1)**.

Using **PRINTNUM** (page 25.15) or the **PRINTOUT** command **.I** (page 25.30) is often a more convenient and appropriate way to print a single number in a specified radix than to globally change **RADIX**.

**(FLTFMT** *FORMAT***)** [Function]

Resets the output format for floating point numbers to the **FLOAT** format *FORMAT* (see **PRINTNUM** below for a description of **FLOAT** formats). *FORMAT* = **T** specifies the default "free" formatting: some number of significant digits (a function of the implementation) are printed, with trailing zeros suppressed;

numbers with sufficiently large or small exponents are instead printed in exponent notation.

**FLTFMT** returns its current setting. **(FLTFMT)** returns the current setting without changing it. The initial setting is **T**.

Note: In Interlisp-D, **FLTFMT** ignores the *WIDTH* and *PAD* fields of the format (they are implemented only by **PRINTNUM**).

Whether print name manipulation functions (**UNPACK**, **NCHARS**, etc.) use the values of **RADIX** and **FLTFMT** is determined by the variable **PRXFLG**:

**PRXFLG** [Variable]

If **PRXFLG** = **NIL** (the initial setting), then the "**PRIN1**" name used by **PACK**, **UNPACK**, **MKSTRING**, etc., is computed using base 10 for integers and the system default floating format for floating point numbers, independent of the current setting of **RADIX** or **FLTFMT**. If **PRXFLG** = **T**, then **RADIX** and **FLTFMT** do dictate the "**PRIN1**" name of numbers. Note that in this case, **PACK** and **UNPACK** are *not* inverses.

Examples with **(RADIX 8)**, **(FLTFMT '(FLOAT 4 2))**:

With **PRXFLG** = **NIL**,

**(UNPACK 13) => (1 3)**

**(PACK '(A 9)) => A9**

**(UNPACK 1.2345) => (1 %. 2 3 4 5)**

With **PRXFLG** = **T**,

**(UNPACK 13) => (1 5)**

**(PACK '(A 9)) => A11**

**(UNPACK 1.2345) => (1 %. 2 3)**

Note that **PRXFLG** does not effect the radix of "**PRIN2**" names, so with **(RADIX 8)**, **(NCHARS 9 T)**, which uses **PRIN2** names, would return 3, (since 9 would print as 11Q) for either setting of **PRXFLG**.

Warning: Some system functions will not work correctly if **PRXFLG** is not **NIL**. Therefore, resetting the global value of **PRXFLG** is not recommended. It is much better to rebind **PRXFLG** as a **SPECVAR** for that part of a program where it needs to be non-**NIL**.

The basic function for printing numbers under format control is **PRINTNUM**. Its utility is considerably enhanced when used in conjunction with the **PRINTOUT** package (page 25.23), which implements a compact language for specifying complicated sequences of elementary printing operations, and makes fancy output formats easy to design and simple to program.

**(PRINTNUM** *FORMAT NUMBER FILE***)** [Function]

Prints *NUMBER* on *FILE* according to the format *FORMAT*. *FORMAT* is a list structure with one of the forms described below.

If *FORMAT* is a list of the form **(FIX** *WIDTH RADIX PAD0 LEFTFLUSH***)**, this specifies a **FIX** format. *NUMBER* is rounded to the nearest integer, and then printed in a field *WIDTH* characters long with radix set to *RADIX* (or 10 if *RADIX* = **NIL**; note that the setting from the function **RADIX** is *not* used as the default). If *PAD0* and *LEFTFLUSH* are both **NIL**, the number is right-justified in the field, and the padding characters to the left of the leading digit are spaces. If *PAD0* is **T**, the character "**0**" is used for padding. If *LEFTFLUSH* is **T**, then the number is left-justified in the field, with trailing spaces to fill out *WIDTH* characters.

The following examples illustrate the effects of the **FIX** format options on the number 9 (the vertical bars indicate the field width):

*FORMAT*: **(PRINTNUM** *FORMAT* **9)** prints:

**(FIX 2)** `| 9|`

**(FIX 2 NIL T)** `|09|`

**(FIX 12 8 T)** `|000000000011|`

**(FIX 5 NIL NIL T)** `|9    |`

If *FORMAT* is a list of the form **(FLOAT** *WIDTH DECPART EXPPART PAD0 ROUND***)**, this specifies a **FLOAT** format. *NUMBER* is printed as a decimal number in a field *WIDTH* characters wide, with *DECPART* digits to the right of the decimal point. If *EXPPART* is not **0** (or **NIL**), the number is printed in exponent notation, with the exponent occupying *EXPPART* characters in the field. *EXPPART* should allow for the character **E** and an optional sign to be printed before the exponent digits. As with **FIX** format, padding on the left is with spaces, unless *PAD0* is **T**. If *ROUND* is given, it indicates the digit position at which rounding is to take place, counting from the leading digit of the number.

Interlisp-D interprets *WIDTH* = **NIL** to mean no padding, i.e., to use however much space the number needs, and interprets *DECPART* = **NIL** to mean as many decimal places as needed.

The following examples illustrate the effects of the **FLOAT** format options on the number 27.689 (the vertical bars indicate the field width):

*FORMAT*: **(PRINTNUM** *FORMAT* **27.689)** prints:

**(FLOAT 7 2)** `|  27.69|`

| | |
|---|---|
| **(FLOAT 7 2 NIL T)** | **\|0027.69\|** |
| **(FLOAT 7 2 2)** | **\| 2.77E1\|** |
| **(FLOAT 11 2 4)** | **\|  2.77E+01\|** |
| **(FLOAT 7 2 NIL NIL 1)** | **\| 30.00\|** |
| **(FLOAT 7 2 NIL NIL 2)** | **\| 28.00\|** |

**NILNUMPRINTFLG** [Variable]

If **PRINTNUM**'s *NUMBER* argument is not a number and not **NIL**, a **NON-NUMERIC ARG** error is generated. If *NUMBER* is **NIL**, the effect depends on the setting of the variable **NILNUMPRINTFLG**. If **NILNUMPRINTFLG** is **NIL**, then the error occurs as usual. If it is non-**NIL**, then no error occurs, and the value of **NILNUMPRINTFLG** is printed right-justified in the field described by *FORMAT*. This option facilitates the printing of numbers in aggregates with missing values coded as **NIL**.

## 25.3.3 User Defined Printing

Initially, Interlisp only knows how to print in an interesting way objects of type litatom, number, string, list and stackp. All other types of objects are printed in the form **{datatype}** followed by the octal representation of the address of the pointer, a format that cannot be read back in to produce an equivalent object. When defining user data types (using the **DATATYPE** record type, page 8.9), it is often desirable to specify as well how objects of that type should be printed, so as to make their contents readable, or at least more informative to the viewer. The function **DEFPRINT** is used to specify the printing format of a data type.

**(DEFPRINT *TYPE FN*)** [Function]

*TYPE* is a type name. Whenever a printing function (**PRINT**, **PRIN1**, **PRIN2**, etc.) or a function requiring a print name (**CHCON**, **NCHARS**, etc.) encounters an object of the indicated type, *FN* is called with two arguments: the item to be printed and the name of the stream, if any, to which the object is to be printed. The second argument is **NIL** on calls that request the print name of an object without actually printing it.

If *FN* returns a list of the form (*ITEM1* . *ITEM2*), *ITEM1* is printed using **PRIN1** (unless it is **NIL**), and then *ITEM2* is printed using **PRIN2** (unless it is **NIL**). No spaces are printed between the two items. Typically, *ITEM1* is a read macro character.

If *FN* returns **NIL**, the datum is printed in the system default manner.

If *FN* returns **T**, nothing further is printed; *FN* is assumed to have printed the object to the stream itself. Note that this case if permitted only when the second argument passed to *FN* is non-**NIL**; otherwise, there is no destination for *FN* to do its printing, so it must return as in one of the other two cases.

## 25.3.4 Printing Unusual Data Structures

**HPRINT** (for "Horrible Print") and **HREAD** provide a mechanism for printing and reading back in general data structures that cannot normally be dumped and loaded easily, such as (possibly re-entrant or circular) structures containing user datatypes, arrays, hash tables, as well as list structures. **HPRINT** will correctly print and read back in any structure containing any or all of the above, chasing all pointers down to the level of literal atoms, numbers or strings. **HPRINT** currently cannot handle compiled code arrays, stack positions, or arbitrary unboxed numbers.

**HPRINT** operates by simulating the Interlisp **PRINT** routine for normal list structures. When it encounters a user datatype (see page 8.20), or an array or hash array, it prints the data contained therein, surrounded by special characters defined as read macro characters (see page 25.39). While chasing the pointers of a structure, it also keeps a hash table of those items it encounters, and if any item is encountered a second time, another read macro character is inserted before the first occurrence (by resetting the file pointer with **SETFILEPTR**) and all subsequent occurrences are printed as a back reference using an appropriate macro character. Thus the inverse function, **HREAD** merely calls the Interlisp **READ** routine with the appropriate read table.

**(HPRINT** *EXPR FILE UNCIRCULAR DATATYPESEEN***)** [Function]

Prints *EXPR* on *FILE*. If *UNCIRCULAR* is non-**NIL**, **HPRINT** does no checking for any circularities in *EXPR* (but is still useful for dumping arbitrary structures of arrays, hash arrays, lists, user data types, etc., that do not contain circularities). Specifying *UNCIRCULAR* as non-**NIL** results in a large speed and internal-storage advantage.

Normally, when **HPRINT** encounters a user data type for the first time, it outputs a summary of the data type's declaration. When this is read in, the data type is redeclared. If *DATATYPESEEN* is non-**NIL**, **HPRINT** assumes that the same data type declarations will be in force at read time as were at **HPRINT** time, and not output declarations.

**HPRINT** is intended primarily for output to random access files, since the algorithm depends on being able to reset the file pointer. If *FILE* is not a random access file (and *UNCIRCULAR* = **NIL**), a temporary file, **HPRINT.SCRATCH**, is opened, *EXPR* is

**HPRINT**ed on it, and then that file is copied to the final output file and the temporary file is deleted.

**(HREAD *FILE*)** [Function]

Reads and returns an **HPRINT**-ed expression from *FILE*.

**(HCOPYALL *X*)** [Function]

Copies data structure *X*. *X* may contain circular pointers as well as arbitrary structures.

Note: **HORRIBLEVARS** and **UGLYVARS** (page 17.36) are two file package commands for dumping and reloading circular and re-entrant data structures. They provide a convenient interface to **HPRINT** and **HREAD**.

When **HPRINT** is dumping a data structure that contains an instance of an Interlisp datatype, the datatype declaration is also printed onto the file. Reading such a data structure with **HREAD** can cause problems if it redefines a system datatype. Redefining a system datatype will almost definitely cause serious errors. The Interlisp system datatypes do not change very often, but there is always a possibility when loading in old files created under an old Interlisp release.

To prevent accidental system crashes, **HREAD** will *not* redefine datatypes. Instead, it will cause an error "**attempt to read DATATYPE with different field specification than currently defined**". Continuing from this error will redefine the datatype.

## 25.4 Random Access File Operations

For most applications, files are read starting at their beginning and proceeding sequentially, i.e., the next character read is the one immediately following the last character read. Similarly, files are written sequentially. However, for files on some devices, it is also possible to read/write characters at arbitrary positions in a file, essentially treating the file as a large block of auxiliary storage. For example, one application might involve writing an expression at the *beginning* of the file, and then reading an expression from a specified point in its *middle*. This particular example requires the file be open for *both* input and output. However, random file input or output can also be performed on files that have been opened for only input or only output.

Associated with each file is a "file pointer" that points to the location where the next character is to be read from or written to. The file position of a byte is the number of bytes that precede it in the file, i.e., 0 is the position of the beginning of the file. The file pointer to a file is automatically advanced after each input or output operation. This section describes functions which can be used to *reposition* the file pointer on those files that can be randomly accessed. A file used in this fashion is much like an array in that it has a certain number of addressable locations that characters can be put into or taken from. However, unlike arrays, files can be enlarged. For example, if the file pointer is positioned at the end of a file and anything is written, the file "grows." It is also possible to position the file pointer *beyond* the end of file and then to write. (If the program attempts to *read* beyond the end of file, an **END OF FILE** error occurs.) In this case, the file is enlarged, and a "hole" is created, which can later be written into. Note that this enlargement only takes place at the *end* of a file; it is not possible to make more room in the middle of a file. In other words, if expression **A** begins at position 1000, and expression **B** at 1100, and the program attempts to overwrite **A** with expression **C**, whose printed representation is 200 bytes long, part of **B** will be altered.

Warning: File positions are always in terms of bytes, not characters. The user should thus be very careful about computing the space needed for an expression. In particular, NS characters may take multiple bytes (see page 25.22). Also, the end-of-line character (see page 24.19) may be represented by a different number of characters in different implementations. Output functions may also introduce end-of-line's as a result of **LINELENGTH** considerations. Therefore **NCHARS** (page 2.9) does *not* specify how many bytes an expression takes to print, even ignoring line length considerations.

**(GETFILEPTR *FILE*)** [Function]

Returns the current position of the file pointer for *FILE*, i.e., the byte address at which the next input/output operation will commence.

**(SETFILEPTR *FILE ADR*)** [Function]

Sets the file pointer for *FILE* to the position *ADR*; returns *ADR*. The special value *ADR* = **-1** is interpreted to mean the address of the end of file.

Note: If a file is opened for output only, the end of file is initially zero, even if an old file by the same name had existed (see **OPENSTREAM**, page 24.2). If a file is opened for both input and output, the initial file pointer is the beginning of the file, but **(SETFILEPTR *FILE* -1)** sets it to the end of the file. If the file had been opened in append mode by **(OPENSTREAM *FILE* 'APPEND)**, the file pointer right after opening would be set to the end of the existing file, in which case a **SETFILEPTR** to position the file at the end would be unnecessary.

**(GETEOFPTR** *FILE***)** [Function]

Returns the byte address of the end of file, i.e., the number of bytes in the file. Equivalent to performing **(SETFILEPTR** *FILE* **-1)** and returning **(GETFILEPTR** *FILE***)** except that it does not change the current file pointer.

**(RANDACCESSP** *FILE***)** [Function]

Returns *FILE* if *FILE* is randomly accessible, **NIL** otherwise. The file **T** is not randomly accessible, nor are certain network file connections in Interlisp-D. *FILE* must be open or an error is generated, **FILE NOT OPEN**.

**(COPYBYTES** *SRCFIL DSTFIL START END***)** [Function]

Copies bytes from *SRCFIL* to *DSTFIL*, starting from position *START* and up to but not including position *END*. Both *SRCFIL* and *DSTFIL* must be open. Returns **T**.

If *END* = **NIL**, *START* is interpreted as the number of bytes to copy (starting at the current position). If *START* is also **NIL**, bytes are copied until the end of the file is reached.

Warning: **COPYBYTES** does not take any account of multi-byte NS characters (page 2.12). **COPYCHARS** (below) should be used whenever copying information that might include NS characters.

**(COPYCHARS** *SRCFIL DSTFIL START END***)** [Function]

Like **COPYBYTES** except that it copies NS characters (page 2.12), and performs the proper conversion if the end-of-line conventions of *SRCFIL* and *DSTFIL* are not the same (see page 24.19). *START* and *END* are interpreted the same as with **COPYBYTES**, i.e., as byte (not character) specifications in *SRCFIL*. The number of bytes actually output to *DSTFIL* might be more or less than the number of bytes specified by *START* and *END*, depending on what the end-of-line conventions are. In the case where the end-of-line conventions happen to be the same, **COPYCHARS** simply calls **COPYBYTES**.

**(FILEPOS** *PATTERN FILE START END SKIP TAIL CASEARRAY***)** [Function]

Analogous to **STRPOS** (page 4.5), but searches a file rather than a string. **FILEPOS** searches *FILE* for the string *PATTERN*. Search begins at *START* (or the current position of the file pointer, if *START* = **NIL**), and goes to *END* (or the end of *FILE*, if *END* = **NIL**). Returns the address of the start of the match, or **NIL** if not found.

*SKIP* can be used to specify a character which matches any character in the file. If *TAIL* is **T**, and the search is successful, the value is the address of the first character *after* the sequence of characters corresponding to *PATTERN*, instead of the starting address of the sequence. In either case, the file is left so that the next i/o operation begins at the address returned as the value of **FILEPOS**.

*CASEARRAY* should be a "case array" that specifies that certain characters should be transformed to other characters before matching. Case arrays are returned by **CASEARRAY** or **SEPRCASE** below. *CASEARRAY* = **NIL** means no transformation will be performed.

A case array is an implementation-dependent object that is logically an array of character codes with one entry for each possible character. **FILEPOS** maps each character in the file "through" *CASEARRAY* in the sense that each character code is transformed into the corresponding character code from *CASEARRAY* before matching. Thus if two characters map into the same value, they are treated as equivalent by **FILEPOS**. **CASEARRAY** and **SETCASEARRAY** provide an implementation-independent interface to case arrays.

For example, to search without regard to upper and lower case differences, *CASEARRAY* would be a case array where all characters map to themselves, except for lower case characters, whose corresponding elements would be the upper case characters. To search for a delimited atom, one could use " *ATOM* " as the pattern, and specify a case array in which all of the break and separator characters mapped into the same code as space.

For applications calling for extensive file searches, the function **FFILEPOS** is often faster than **FILEPOS**.

**(FFILEPOS** *PATTERN FILE START END SKIP TAIL CASEARRAY***)** [Function]

Like **FILEPOS**, except much faster in most applications. **FFILEPOS** is an implementation of the Boyer-Moore fast string searching algorithm. This algorithm preprocesses the string being searched for and then scans through the file in steps usually equal to the length of the string. Thus, **FFILEPOS** speeds up roughly in proportion to the length of the string, e.g., a string of length 10 will be found twice as fast as a string of length 5 in the same position.

Because of certain fixed overheads, it is generally better to use **FILEPOS** for short searches or short strings.

**(CASEARRAY** *OLDARRAY***)** [Function]

Creates and returns a new case array, with all elements set to themselves, to indicate the identity mapping. If *OLDARRAY* is given, it is reused.

**(SETCASEARRAY** *CASEARRAY FROMCODE TOCODE***)** [Function]

Modifies the case array *CASEARRAY* so that character code *FROMCODE* is mapped to character code *TOCODE*.

**(GETCASEARRAY** *CASEARRAY FROMCODE***)** [Function]

Returns the character code that *FROMCODE* is mapped to in *CASEARRAY*.

**(SEPRCASE** *CLFLG***)** [Function]

Returns a new case array suitable for use by **FILEPOS** or **FFILEPOS** in which all of the break/separators of **FILERDTBL** are mapped into character code zero. If *CLFLG* is non-**NIL**, then all CLISP characters are mapped into this character as well. This is useful for finding a delimited atom in a file. For example, if *PATTERN* is **" FOO "**, and **(SEPRCASE T)** is used for *CASEARRAY*, then **FILEPOS** will find **"(FOO←"**.

**UPPERCASEARRAY** [Variable]

Value is a case array in which every lowercase character is mapped into the corresponding uppercase character. Useful for searching text files.

## 25.5 Input/Output Operations with Characters and Bytes

Interlisp-D supports the 16-bit NS character set (see page 2.12). All of the standard string and print name functions accept litatoms and strings containing NS characters. In almost all cases, a program does not have to distinguish between NS characters or 8-bit characters. The exception to this rule is the handling of input/output operations.

Interlisp-D uses two ways of writing 16-bit NS characters on files. One way is to write the full 16-bits (two bytes) every time a character is output. The other way is to use "run-encoding." Each 16 NS character can be decoded into a character set (an integer from 0 to 254 inclusive) and a character number (also an integer from 0 to 254 inclusive). In run-encoding, the byte 255 (illegal as either a character set number or a character number) is used to signal a change to a given character set, and the following bytes are all assumed to come from the same character set (until the next change-character set sequence). Run-encoding can reduce the number of bytes required to encode a string of NS characters, as long as there are long sequences of characters from the same character set (usually the case).

*Note that characters are not the same as bytes.* A single character can take anywhere from one to four bytes bytes, depending on whether it is in the same character set as the preceeding character, and whether run-encoding is enabled. Programs which assume that characters are equal to bytes must be changed to work with NS characters.

The functions **BIN** (page 25.5) and **BOUT** (page 25.9) should only be used to read and write single eight-bit bytes. The functions **READCCODE** (page 25.5)and **PRINTCCODE** (page 25.9) should be used to read and write single character codes, interpreting run-encoded NS characters. **COPYBYTES** (page 25.20) should only be used to copy blocks of 8-bit data; **COPYCHARS** should be used to copy characters. Most I/O functions (**READC**, **PRIN1**, etc.) read or write 16-bit NS characters.

The use of NS characters has serious consequences for any program that uses file pointers to access a file in a random access manner. At any point when a file is being read or written, it has a "current character set." If the file pointer is changed with **SETFILEPTR** (page 25.19) to a part of the file with a different character set, any characters read or written may have the wrong character set. The current character set can be accessed with the following function:

**(CHARSET** ***STREAM CHARACTERSET*****)** [Function]

Returns the current character set of the stream *STREAM*. If *CHARACTERSET* is non-**NIL**, the current character set for *STREAM* is set. Note that for output streams this may cause bytes to be written to the stream.

If *CHARACTERSET* is **T**, run encoding for *STREAM* is disabled: both the character set and the character number (two bytes total) will be written to the stream for each character printed.

## 25.6 PRINTOUT

Interlisp provides many facilities for controlling the format of printed output. By executing various sequences of **PRIN1**, **PRIN2**, **TAB**, **TERPRI**, **SPACES**, **PRINTNUM**, and **PRINTDEF**, almost any effect can be achieved. **PRINTOUT** implements a compact language for specifying complicated sequences of these elementary printing functions. It makes fancy output formats easy to design and simple to program.

**PRINTOUT** is a CLISP word (like **FOR** and **IF**) for interpreting a special printing language in which the user can describe the kinds of printing desired. The description is translated by **DWIMIFY** to the appropriate sequence of **PRIN1**, **TAB**, etc., before it is evaluated or compiled. **PRINTOUT** printing descriptions have the following general form:

**(PRINTOUT** *STREAM PRINTCOM$_1$* ... *PRINTCOM$_N$***)**

*STREAM* is evaluated to obtain the stream to which the output from this specification is directed. The **PRINTOUT** commands are strung together, one after the other without punctuation, after *STREAM*. Some commands occupy a single position in this list, but many commands expect to find arguments following the command name in the list. The commands fall into several logical groups: one set deals with horizontal and vertical spacing, another group provides controls for certain formatting capabilities (font changes and subscripting), while a third set is concerned with various ways of actually printing items. Finally, there is a command that permits escaping to a simple Lisp evaluation in the middle of a **PRINTOUT** form. The various commands are described below. The following examples give a general flavor of how **PRINTOUT** is used:

Example 1: Suppose the user wanted to print out on the terminal the values of three variables, **X**, **Y**, and **Z**, separated by spaces and followed by a carriage return. This could be done by:

```
(PRIN1 X T)
(SPACES 1 T)
(PRIN1 Y T)
(SPACES 1 T)
(PRIN1 Z T)
(TERPRI T)
```

or by the more concise **PRINTOUT** form:

```
(PRINTOUT T X , Y , Z T)
```

Here the first **T** specifies output to the terminal, the commas cause single spaces to be printed, and the final **T** specifies a **TERPRI**. The variable names are not recognized as special **PRINTOUT** commands, so they are printed using **PRIN1** by default.

Example 2: Suppose the values of **X** and **Y** are to be pretty-printed lined up at position 10, preceded by identifying strings. If the output is to go to the primary output stream, the user could write either:

```
(PRIN1 "X = ")
(PRINTDEF X 10 T)
(TERPRI )
(PRIN1 "Y = ")
(PRINTDEF Y 10 T)
(TERPRI)
```

or the equivalent:

```
(PRINTOUT NIL "X = " 10 .PPV X T
```

```
"Y = " 10 .PPV Y T)
```

Since strings are not recognized as special commands, **"X = "** is also printed with **PRIN1** by default. The positive integer means **TAB** to position 10, where the **.PPV** command causes the value of **X** to be prettyprinted as a variable. By convention, special atoms used as **PRINTOUT** commands are prefixed with a period. The **T** causes a carriage return, so the **Y** information is printed on the next line.

Example 3. As a final example, suppose that the value of **X** is an integer and the value of **Y** is a floating-point number. **X** is to be printed right-flushed in a field of width 5 beginning at position 15, and **Y** is to be printed in a field of width 10 also starting at position 15 with 2 places to the right of the decimal point. Furthermore, suppose that the variable names are to appear in the font class named **BOLDFONT** and the values in font class **SMALLFONT**. The program in ordinary Interlisp that would accomplish these effects is too complicated to include here. With **PRINTOUT**, one could write:

```
(PRINTOUT NIL
  .FONT BOLDFONT "X = " 15
  .FONT SMALLFONT .I5 X T
  .FONT BOLDFONT "Y = " 15
  .FONT SMALLFONT .F10.2 Y T
  .FONT BOLDFONT)
```

The **.FONT** commands do whatever is necessary to change the font on a multi-font output device. The **.I5** command sets up a **FIX** format for a call to the function **PRINTNUM** (page 25.15) to print **X** in the desired format. The **.F10.2** specifies a **FLOAT** format for **PRINTNUM**.

## 25.6.1 Horizontal Spacing Commands

The horizontal spacing commands provide convenient ways of calling **TAB** and **SPACES**. In the following descriptions, *N* stands for a literal positive integer (*not* for a variable or expression whose value is an integer).

***N* (*N* a number)** [PRINTOUT command]

Used for absolute spacing. It results in a **TAB** to position *N* (literally, a **(TAB** ***N*)**). If the line is currently at position *N* or beyond, the file will be positioned at position *N* on the next line.

**.TAB** *POS* [PRINTOUT command]

Specifies **TAB** to position (the value of) *POS*. This is one of several commands whose effect could be achieved by simply escaping to Lisp, and executing the corresponding form. It is provided as a separate command so that the **PRINTOUT** form is more concise and is prettyprinted more compactly. Note that **.TAB** *N* and *N*,' where *N* is an integer, are equivalent.

**.TAB0** *POS* [PRINTOUT command]

Like **.TAB** except that it can result in zero spaces (i.e. the call to **TAB** specifies *MINSPACES* = 0).

**-*N*** **(*N* a number)** [PRINTOUT command]

Negative integers indicate relative (as opposed to absolute) spacing. Translates as **(SPACES** |*N*|**)**.

**,** [PRINTOUT command]

**,,** [PRINTOUT command]

**,,,** [PRINTOUT command]

(1, 2 or 3 commas) Provides a short-hand way of specifying 1, 2 or 3 spaces, i.e., these commands are equivalent to **-1**, **-2**, and **-3**, respectively.

**.SP** *DISTANCE* [PRINTOUT command]

Translates as **(SPACES** *DISTANCE***)**. Note that **.SP** *N* and **-*N***, where *N* is an integer, are equivalent.

## 25.6.2 Vertical Spacing Commands

Vertical spacing is obtained by calling **TERPRI** or printing form-feeds. The relevant commands are:

**T** [PRINTOUT command]

Translates as **(TERPRI)**, i.e., move to position 0 (the first column) of the next line. To print the letter **T**, use the string **"T"**.

**.SKIP** *LINES* [PRINTOUT command]

Equivalent to a sequence of *LINES* **(TERPRI)**'s. The **.SKIP** command allows for skipping large constant distances and for computing the distance to be skipped.

**.PAGE** [PRINTOUT command]

Puts a form-feed (control-L) out on the file. Care is taken to make sure that Interlisp's view of the current line position is correctly updated.

### 25.6.3 Special Formatting Controls

There are a small number of commands for invoking some of the formatting capabilities of multi-font output devices. The available commands are:

**.FONT** *FONTSPEC* [PRINTOUT command]

Changes printing to the font *FONTSPEC*, which can be a font descriptor, a "font list" such as **'(MODERN 10)**, an image stream (coerced to its current font), or a windows (coerced to the current font of its display stream). See fonts (page 27.25) for more information.

*FONTSPEC* may also be a positive integer *N*, which is taken as an abbreviated reference to the font class named **FONT***N* (e.g. 1 = > **FONT1**).

**.SUP** [PRINTOUT command]

Specifies superscripting. All subsequent characters are printed above the base of the current line. Note that this is absolute, not relative: a **.SUP** following a **.SUP** is a no-op.

**.SUB** [PRINTOUT command]

Specifies subscripting. Subsequent printing is below the base of the current line. As with superscripting, the effect is absolute.

**.BASE** [PRINTOUT command]

Moves printing back to the base of the current line. Un-does a previous **.SUP** or **.SUB**; a no-op, if printing is currently at the base.

### 25.6.4 Printing Specifications

The value of any expression in a **PRINTOUT** form that is not recognized as a command itself or as a command argument is printed using **PRIN1** by default. For example, title strings can be printed by simply including the string as a separate **PRINTOUT** command, and the values of variables and forms can be printed in much the same way. Note that a literal integer, say 51, cannot be printed by including it as a command, since it would be interpreted as a **TAB**; the desired effect can be obtained by using instead the string specification "51", or the form **(QUOTE 51)**.

For those instances when **PRIN1** is not appropriate, e.g., **PRIN2** is required, or a list structures must be prettyprinted, the following commands are available:

**.P2** *THING* [PRINTOUT command]

Causes *THING* to be printed using **PRIN2**; translates as **(PRIN2** *THING***)**.

**.PPF** *THING* [PRINTOUT command]

Causes *THING* to be prettyprinted at the current line position via **PRINTDEF** (page 26.42). The call to **PRINTDEF** specifies that *THING* is to be printed as if it were part of a function definition. That is, **SELECTQ, PROG**, etc., receive special treatment.

**.PPV** *THING* [PRINTOUT command]

Prettyprints *THING* as a variable; no special interpretation is given to **SELECTQ, PROG**, etc.

**.PPFTL** *THING* [PRINTOUT command]

Like **.PPF**, but prettyprints *THING* as a *tail*, that is, without the initial and final parentheses if it is a list. Useful for prettyprinting sub-lists of a list whose other elements are formatted with other commands.

**.PPVTL** *THING* [PRINTOUT command]

Like **.PPV**, but prettyprints *THING* as a tail.

### 25.6.4.1 Paragraph Format

Interlisp's prettyprint routines are designed to display the structure of expressions, but they are not really suitable for formatting unstructured text. If a list is to be printed as a textual paragraph, its internal structure is less important than controlling its left and right margins, and the indentation of its first line. The **.PARA** and **.PARA2** commands allow these parameters to be conveniently specified.

**.PARA** *LMARG RMARG LIST* [PRINTOUT command]

Prints *LIST* in paragraph format, using **PRIN1**. Translates as **(PRINTPARA** *LMARG RMARG LIST***)** (see page 25.32).

Example: **(PRINTOUT T 10 .PARA 5 -5 LST)** will print the elements of **LST** as a paragraph with left margin at 5, right margin at **(LINELENGTH)**-5, and the first line indented to 10.

**.PARA2** *LMARG RMARG LIST* [PRINTOUT command]

Print as paragraph using **PRIN2** instead of **PRIN1**. Translates as **(PRINTPARA** *LMARG RMARG LIST* **T)**.

### 25.6.4.2 Right-Flushing

Two commands are provided for printing simple expressions flushed-right against a specified line position, using the function **FLUSHRIGHT** (page 25.32). They take into account the current position, the number of characters in the print-name of the expression, and the position the expression is to be flush against, and then print the appropriate number of spaces to achieve the desired effect. Note that this might entail going to a new line before printing. Note also that right-flushing of expressions longer than a line (e.g. a large list) makes little sense, and the appearance of the output is not guaranteed.

**.FR** *POS EXPR* [PRINTOUT command]

Flush-right using **PRIN1**. The value of *POS* determines the position that the right end of *EXPR* will line up at. As with the horizontal spacing commands, a negative position number means |*POS*| columns from the current position, a positive number specifies the position absolutely. *POS* = 0 specifies the right-margin, i.e. is interpreted as **(LINELENGTH)**.

**.FR2** *POS EXPR* [PRINTOUT command]

Flush-right using **PRIN2** instead of **PRIN1**.

### 25.6.4.3 Centering

Commands for centering simple expressions between the current line position and another specified position are also available. As with right flushing, centering of large expressions is not guaranteed.

**.CENTER** *POS EXPR* [PRINTOUT command]

Centers *EXPR* between the current line position and the position specified by the value of *POS*. A positive *POS* is an absolute position number, a negative *POS* specifies a position relative to the current position, and 0 indicates the right-margin. Uses **PRIN1** for printing.

**.CENTER2** *POS EXPR* [PRINTOUT command]

Centers using **PRIN2** instead of **PRIN1**.

### 25.6.4.4 Numbering

The following commands provide FORTRAN-like formatting capabilities for integer and floating-point numbers. Each command specifies a printing format and a number to be printed. The format specification translates into a format-list for the function **PRINTNUM** (see page 25.15).

*.IFORMAT NUMBER* [PRINTOUT command]

Specifies integer printing. Translates as a call to the function **PRINTNUM** with a **FIX** format-list constructed from *FORMAT*. The atomic format is broken apart at internal periods to form the format-list. For example, **.I5.8.T** yields the format-list **(FIX 5 8 T)**, and the command sequence **(PRINTOUT T .I5.8.T FOO)** translates as **(PRINTNUM '(FIX 5 8 T) FOO)**. This expression causes the value of **FOO** to be printed in radix 8 right-flushed in a field of width 5, with 0's used for padding on the left. Internal **NIL**'s in the format specification may be omitted, e.g., the commands **.I5..T** and **.I5.NIL.T** are equivalent.

The format specification **.I1** is often useful for forcing a number to be printed in radix 10 (but not otherwise specially formatted), independent of the current setting of **RADIX**.

*.FFORMAT NUMBER* [PRINTOUT command]

Specifies floating-number printing. Like the **.I** format command, except translates with a **FLOAT** format-list.

**.N** *FORMAT NUMBER* [PRINTOUT command]

The **.I** and **.F** commands specify calls to **PRINTNUM** with quoted format specifications. The **.N** command translates as **(PRINTNUM** *FORMAT NUMBER***)**, i.e., it permits the format to be the value of some expression. Note that, unlike the **.I** and **.F** commands, *FORMAT* is a separate element in the command list, not part of an atom beginning with **.N**.

## 25.6.5 Escaping to Lisp

There are many reasons for taking control away from **PRINTOUT** in the middle of a long printing expression. Common situations involve temporary changes to system printing parameters (e.g. **LINELENGTH**), conditional printing (e.g. print **FOO** only if **FIE** is **T**), or lower-level iterative printing within a higher-level print specification.

*# FORM* [PRINTOUT command]

The escape command. *FORM* is an arbitrary Lisp expression that is evaluated within the context established by the **PRINTOUT** form, i.e., *FORM* can assume that the primary output stream has been set to be the *FILE* argument to **PRINTOUT**. Note that nothing is done with the *value* of *FORM*; any printing desired is accomplished by *FORM* itself, and the value is discarded.

Note: Although **PRINTOUT** logically encloses its translation in a **RESETFORM** (page 14.26) to change the primary output file to the *FILE* argument (if non-**NIL**), in most cases it can actually pass *FILE* (or a locally bound variable if *FILE* is a non-trivial expression) to each printing function. Thus, the **RESETFORM** is only generated when the # command is used, or user-defined commands (below) are used. If many such occur in repeated **PRINTOUT** forms, it may be more efficient to embed them all in a single **RESETFORM** which changes the primary output file, and then specify *FILE* = **NIL** in the **PRINTOUT** expressions themselves.

## 25.6.6 User-Defined Commands

The collection of commands and options outlined above is aimed at fulfilling all common printing needs. However, certain applications might have other, more specialized printing idioms, so a facility is provided whereby the user can define new commands. This is done by adding entries to the global list **PRINTOUTMACROS** to define how the new commands are to be translated.

**PRINTOUTMACROS** [Variable]

**PRINTOUTMACROS** is an association-list whose elements are of the form (*COMM FN*). Whenever *COMM* appears in command position in the sequence of **PRINTOUT** commands (as opposed to an argument position of another command), *FN* is applied to the tail of the command-list (including the command).

After inspecting as much of the tail as necessary, the function must return a list whose **CAR** is the translation of the user-defined command and its arguments, and whose **CDR** is the list of commands still remaining to be translated in the normal way.

For example, suppose the user wanted to define a command "?", which will cause its single argument to be printed with **PRIN1** only if it is not **NIL**. This can be done by entering **(? ?TRAN)** on **PRINTOUTMACROS**, and defining the function **?TRAN** as follows:

```
(DEFINEQ (?TRAN (COMS)
  (CONS
   (SUBST (CADR COMS) 'ARG
     '(PROG ((TEMP ARG))
        (COND (TEMP (PRIN1 TEMP)))))
   (CDDR COMS))]
```

Note that **?TRAN** does not do any printing itself; it returns a form which, when evaluated in the proper context, will perform the desired action. This form should direct all printing to the primary output file.

### 25.6.7 Special Printing Functions

The paragraph printing commands are translated into calls on the function **PRINTPARA**, which may also be called directly:

**(PRINTPARA** *LMARG RMARG LIST P2FLAG PARENFLAG FILE***)** [Function]

Prints *LIST* on *FILE* in line-filled paragraph format with its first element beginning at the current line position and ending at or before *RMARG*, and with subsequent lines appearing between *LMARG* and *RMARG*. If *P2FLAG* is non-**NIL**, prints elements using **PRIN2**, otherwise **PRIN1**. If *PARENFLAG* is non-**NIL**, then parentheses will be printed around the elements of *LIST*.

If *LMARG* is zero or positive, it is interpreted as an absolute column position. If it is negative, then the left margin will be at |*LMARG*| + **(POSITION)**. If *LMARG* = **NIL**, the left margin will be at **(POSITION)**, and the paragraph will appear in block format.

If *RMARG* is positive, it also is an absolute column position (which may be greater than the current **(LINELENGTH)**). Otherwise, it is interpreted as relative to **(LINELENGTH)**, i.e., the right margin will be at **(LINELENGTH)** + |*RMARG*|. Example: **(TAB 10) (PRINTPARA 5 -5 LST T)** will **PRIN2** the elements of **LST** in a paragraph with the first line beginning at column 10, subsequent lines beginning at column 5, and all lines ending at or before **(LINELENGTH)**-5.

The current **(LINELENGTH)** is unaffected by **PRINTPARA**, and upon completion, *FILE* will be positioned immediately after the last character of the last item of *LIST*. **PRINTPARA** is a no-op if *LIST* is not a list.

The right-flushing and centering commands translate as calls to the function **FLUSHRIGHT**:

**(FLUSHRIGHT** *POS X MIN P2FLAG CENTERFLAG FILE***)** [Function]

If *CENTERFLAG* = **NIL**, prints *X* right-flushed against position *POS* on *FILE*; otherwise, centers *X* between the current line position and *POS*. Makes sure that it spaces over at least *MIN* spaces before printing by doing a **TERPRI** if necessary; *MIN* = **NIL** is equivalent to *MIN* = 1. A positive *POS* indicates an absolute position, while a negative *POS* signifies the position which is |*POS*| to the right of the current line position. *POS* = 0 is interpreted as **(LINELENGTH)**, the right margin.

## 25.7 READFILE and WRITEFILE

For those applications where the user simply wants to simply read all of the expressions on a file, and not evaluate them, the function **READFILE** is available:

**(READFILE** *FILE RDTBL ENDTOKEN***)** [NoSpread Function]

Reads successive expressions from file using **READ** (with read table *RDTBL*) until the single litatom *ENDTOKEN* is read, or an end of file encountered. Returns a list of these expressions.

If *RDTBL* is not specified, it defaults to **FILERDTBL**. If *ENDTOKEN* is not specified, it defaults to the litatom **STOP**.

**(WRITEFILE** *X FILE***)** [Function]

Writes a date expression onto *FILE*, followed by successive expressions from *X*, using **FILERDTBL** as a read table. If *X* is atomic, its value is used. If *FILE* is not open, it is opened. If *FILE* is a list, **(CAR** *FILE***)** is used and the file is left opened. Otherwise, when *X* is finished, the litatom **STOP** is printed on *FILE* and it is closed. Returns *FILE*.

**(ENDFILE** *FILE***)** [Function]

Prints **STOP** on *FILE* and closes it.

## 25.8 Read Tables

Many Interlisp input functions treat certain characters in special ways. For example, **READ** recognizes that the right and left parenthesis characters are used to specify list structures, and that the quote character is used to delimit text strings. The Interlisp input and (to a certain extent) output routines are table driven by read tables. Read tables are objects that specify the syntactic properties of characters for input routines. Since the input routines parse character sequences into objects, the read table in use determines which sequences are recognized as literal atoms, strings, list structures, etc.

Most Interlisp input functions take an optional read table argument, which specifies the read table to use when reading an expression. If **NIL** is given as the read table, the "primary read table" is used. If **T** is specified, the system terminal read table is used. Some functions will also accept the atom **ORIG** (*not* the *value* of **ORIG**) as indicating the "original" system read table. Some output functions also take a read table argument. For example, **PRIN2** prints an expression so that it would be read in correctly using a given read table.

The Interlisp-D system uses the following read tables: **T** for input/output from terminals, the value of **FILERDTBL** for input/output from files, the value of **EDITRDTBL** for input from terminals while in the tty-based editor, the value of **DEDITRDTBL** for input from terminals while in the display-based editor, and the value of **CODERDTBL** for input/output from compiled files. These five read tables are initially copies of the **ORIG** read table, with changes made to some of them to provide read macros (page 25.39) that are specific to terminal input or file input. Using the functions described below, the user may further change, reset, or copy these tables. However, in the case of **FILERDTBL** and **CODERDTBL**, the user is cautioned that changing these tables may prevent the system from being able to read files made with the original tables, or prevent users possessing only the standard tables from reading files made using the modified tables.

The user can also create new read tables, and either explicitly pass them to input/output functions as arguments, or install them as the primary read table, via **SETREADTABLE**, and then not specify a *RDTBL* argument, i.e., use **NIL**.

## 25.8.1 Read Table Functions

**(READTABLEP** *RDTBL***)** [Function]

Returns *RDTBL* if *RDTBL* is a real read table (*not* **T** or **ORIG**), otherwise **NIL**.

**(GETREADTABLE** *RDTBL***)** [Function]

If *RDTBL* = **NIL**, returns the primary read table. If *RDTBL* = **T**, returns the system terminal read table. If *RDTBL* is a real read table, returns *RDTBL*. Otherwise, generates an **ILLEGAL READTABLE** error.

**(SETREADTABLE** *RDTBL FLG***)** [Function]

Sets the primary read table to *RDTBL*. If *FLG* = **T**, **SETREADTABLE** sets the system terminal read table, **T**. Note that the user can reset the other system read tables with **SETQ**, e.g., **(SETQ FILERDTBL (GETREADTABLE))**.

Generates an **ILLEGAL READTABLE** error if *RDTBL* is not **NIL**, **T**, or a real read table. Returns the previous setting of the primary read table, so **SETREADTABLE** is suitable for use with **RESETFORM** (page 14.26).

**(COPYREADTABLE *RDTBL*)** [Function]

Returns a copy of *RDTBL*. *RDTBL* can be a real read table, **NIL**, **T**, or **ORIG** (in which case **COPYREADTABLE** returns a copy of the *original* system read table), otherwise **COPYREADTABLE** generates an **ILLEGAL READTABLE** error.

Note that **COPYREADTABLE** is the only function that *creates* a read table.

**(RESETREADTABLE *RDTBL FROM*)** [Function]

Copies (smashes) *FROM* into *RDTBL*. *FROM* and *RDTBL* can be **NIL**, **T**, or a real read table. In addition, *FROM* can be **ORIG**, meaning use the system's original read table.

## 25.8.2 Syntax Classes

A read table is an object that contains information about the "syntax class" of each character. There are nine basic syntax classes: **LEFTPAREN**, **RIGHTPAREN**, **LEFTBRACKET**, **RIGHTBRACKET**, **STRINGDELIM**, **ESCAPE**, **BREAKCHAR**, **SEPRCHAR**, and **OTHER**, each associated with a primitive syntactic property. In addition, there is an unlimited assortment of user-defined syntax classes, known as "read macros". The basic syntax classes are interpreted as follows:

**LEFTPAREN** (normally left parenthesis) Begins list structure.

**RIGHTPAREN** (normally right parenthesis) Ends list structure.

**LEFTBRACKET** (normally left bracket) Begins list structure. Also matches **RIGHTBRACKET** characters.

**RIGHTBRACKET** (normally left bracket) Ends list structure. Can close an arbitrary numbers of **LEFTPAREN** lists, back to the last **LEFTBRACKET**.

**STRINGDELIM** (normally double quote) Begins and ends text strings. Within the string, all characters except for the one(s) with class **ESCAPE** are treated as ordinary, i.e., interpreted as if they were of syntax class **OTHER**. To include the string delimiter inside a string, prefix it with the **ESCAPE** character.

**ESCAPE** (normally percent sign) Inhibits any special interpretation of the next character, i.e., the next character is interpreted to be of class **OTHER**, independent of its normal syntax class.

**BREAKCHAR** (None initially) Is a break character, i.e., delimits atoms, but is otherwise an ordinary character.

**SEPRCHAR** (space, carriage return, etc.) Delimits atoms, and is otherwise ignored.

**OTHER** Characters that are not otherwise special belong to the class **OTHER**.

Characters of syntax class **LEFTPAREN**, **RIGHTPAREN**, **LEFTBRACKET**, **RIGHTBRACKET**, and **STRINGDELIM** are all *break* characters. That is, in addition to their interpretation as delimiting list or string structures, they also terminate the reading of an atom. Characters of class **BREAKCHAR** serve *only* to terminate atoms, with no other special meaning. In addition, if a break character is the first non-separator encountered by **RATOM**, it is read as a one-character atom. In order for a break character to be included in an atom, it must be preceded by the **ESCAPE** character.

Characters of class **SEPRCHAR** also terminate atoms, but are otherwise completely ignored; they can be thought of as logically spaces. As with break characters, they must be preceded by the **ESCAPE** character in order to appear in an atom.

For example, if **$** were a break character and * a separator character, the input stream **ABC**DEF$GH*$$** would be read by 6 calls to **RATOM** returning respectively **ABC, DEF, $, GH, $, $**.

Although normally there is only one character in a read table having each of the list- and string-delimiting syntax classes (such as **LEFTPAREN**), it is perfectly acceptable for any character to have any syntax class, and for more than one to have the same class.

Note that a "syntax class" is an abstraction: there is no object referencing a collection of characters called a *syntax class*. Instead, a read table provides the *association* between a character and its syntax class, and the input/output routines enforce the abstraction by using read tables to drive the parsing.

The functions below are used to obtain and set the syntax class of a character in a read table. *CH* can either be a character code (a integer), or a character (a single-character atom). Single-digit integers are interpreted as character codes, rather than as characters. For example, 1 indicates control-A, and 49 indicates the *character* 1. Note that *CH* can be a full sixteen-bit NS character (see page 2.12).

Note: Terminal tables, described on page 30.4, also associate characters with syntax classes, and they can also be manipulated with the functions below. The set of read table and terminal table syntax classes are disjoint, so there is never any ambiguity about which type of table is being referred to.

**(GETSYNTAX** *CH TABLE***)** [Function]

Returns the syntax class of *CH*, a character or a character code, with respect to *TABLE*. *TABLE* can be **NIL**, **T**, **ORIG**, or a real read table or terminal table.

*CH* can also be a syntax class, in which case **GETSYNTAX** returns a list of the character codes in *TABLE* that have that syntax class.

**(SETSYNTAX** *CHAR CLASS TABLE*) [Function]

Sets the syntax class of *CHAR*, a character or character code, in *TABLE*. *TABLE* can be either **NIL**, **T**, or a real read table or terminal table. **SETSYNTAX** returns the previous syntax class of *CHAR*. *CLASS* can be any one of the following:

- The name of one of the basic syntax classes.
- A list, which is interpreted as a read macro (see page 25.39).
- **NIL**, **T**, **ORIG**, or a real read table or terminal table, which means to give *CHAR* the syntax class it has in the table indicated by *CLASS*. For example, **(SETSYNTAX '%( 'ORIG** *TABLE*) gives the left parenthesis character in *TABLE* the same syntax class that it has in the original system read table.
- A character code or character, which means to give *CHAR* the same syntax class as the character *CHAR* in *TABLE*. For example, **(SETSYNTAX '{ '%[** *TABLE*) gives the left brace character the same syntax class as the left bracket.

**(SYNTAXP** *CODE CLASS TABLE*) [Function]

*CODE* is a character code; *TABLE* is **NIL**, **T**, or a real read table or terminal table. Returns **T** if *CODE* has the syntax class *CLASS* in *TABLE*; **NIL** otherwise.

*CLASS* can also be a read macro type (**MACRO**, **SPLICE**, **INFIX**), or a read macro option (**FIRST**, **IMMEDIATE**, etc.), in which case **SYNTAXP** returns **T** if the syntax class is a read macro with the specified property.

Note: **SYNTAXP** will *not* accept a character as an argument, only a character *code*.

For convenience in use with **SYNTAXP**, the atom **BREAK** may be used to refer to *all* break characters, i.e., it is the union of **LEFTPAREN**, **RIGHTPAREN**, **LEFTBRACKET**, **RIGHTBRACKET**, **STRINGDELIM**, and **BREAKCHAR**. For purely symmetrical reasons, the atom **SEPR** corresponds to all separator characters. However, since the only separator characters are those that also appear in **SEPRCHAR**, **SEPR** and **SEPRCHAR** are equivalent.

Note that **GETSYNTAX** never returns **BREAK** or **SEPR** as a value although **SETSYNTAX** and **SYNTAXP** accept them as arguments. Instead, **GETSYNTAX** returns one of the disjoint basic syntax classes that comprise **BREAK**. **BREAK** as an argument to **SETSYNTAX** is interpreted to mean **BREAKCHAR** if the character is not already of one of the **BREAK** classes. Thus, if **%(** is of class **LEFTPAREN**, then **(SETSYNTAX '%( 'BREAK)** doesn't do anything, since **%(** is already a break character, but **(SETSYNTAX '%( 'BREAKCHAR)** means make **%(** be *just* a break character, and therefore disables the **LEFTPAREN** function of **%(**. Similarly, if one of the format characters is disabled completely, e.g., by

**(SETSYNTAX '%( 'OTHER)**, then **(SETSYNTAX '%( 'BREAK)** would make **%(** be *only* a break character; it would *not* restore **%(** as **LEFTPAREN**.

The following functions provide a way of collectively accessing and setting the separator and break characters in a read table:

**(GETSEPR** *RDTBL***)** [Function]

Returns a list of separator character codes in *RDTBL*. Equivalent to **(GETSYNTAX 'SEPR** *RDTBL***)**.

**(GETBRK** *RDTBL***)** [Function]

Returns a list of break character codes in *RDTBL*. Equivalent to **(GETSYNTAX 'BREAK** *RDTBL***)**.

**(SETSEPR** *LST FLG RDTBL***)** [Function]

Sets or removes the separator characters for *RDTBL*. *LST* is a list of charactors or character codes. *FLG* determines the action of **SETSEPR** as follows: If *FLG* = **NIL**, makes *RDTBL* have exactly the elements of *LST* as separators, discarding from *RDTBL* any old separator characters not in *LST*. If *FLG* = 0, removes from *RDTBL* as separator characters all elements of *LST*. This provides an "**UNSETSEPR**". If *FLG* = 1, makes each of the characters in *LST* be a separator in *RDTBL*.

If *LST* = **T**, the separator characters are reset to be those in the system's read table for terminals, regardless of the value of *FLG*, i.e., **(SETSEPR T)** is equivalent to **(SETSEPR (GETSEPR T))**. If *RDTBL* is **T**, then the characters are reset to those in the original system table.

Returns **NIL**.

**(SETBRK** *LST FLG RDTBL***)** [Function]

Sets the break characters for *RDTBL*. Similar to **SETSEPR**.

As with **SETSYNTAX** to the **BREAK** class, if any of the list- or string-delimiting break characters are disabled by an appropriate **SETBRK** (or by making it be a separator character), its special action for **READ** will *not* be restored by simply making it be a break character again with **SETBRK**. However, making these characters be break characters when they already *are* will have no effect.

The action of the **ESCAPE** character (normally **%**) is not affected by **SETSEPR** or **SETBRK**. It can be disabled by setting its syntax to the class **OTHER**, and other characters can be used for escape on input by assigning them the class **ESCAPE**. As of this writing, however, there is no way to change the output escape character; it is "hardwired" as **%**. That is, on output, characters of special syntax that need to be preceded by the **ESCAPE** character will always be preceded by %, independent of the syntax of % or which, if any characters, have syntax **ESCAPE**.

The following function can be used for defeating the action of the **ESCAPE** character or characters:

**(ESCAPE** *FLG RDTBL***)** [Function]

If *FLG* = **NIL**, makes characters of class **ESCAPE** behave like characters of class **OTHER** on input. Normal setting is **(ESCAPE T)**. **ESCAPE** returns the previous setting.

## 25.8.3 Read Macros

Read macros are user-defined syntax classes that can cause complex operations when certain characters are read. Read macro characters are defined by specifying as a syntax class an expression of the form:

**(***TYPE OPTION*$_1$ ... *OPTION*$_N$ *FN***)**

where *TYPE* is one of **MACRO**, **SPLICE**, or **INFIX**, and *FN* is the name of a function or a lambda expression. Whenever **READ** encounters a read macro character, it calls the associated function, giving it as arguments the input stream and read table being used for that call to **READ**. The interpretation of the value returned depends on the type of read macro:

**MACRO** This is the simplest type of read macro. The result returned from the macro is treated as the expression to be read, instead of the read macro character. Often the macro reads more input itself. For example, in order to cause **~EXPR** to be read as **(NOT EXPR)**, one could define ~ as the read macro:

```
[MACRO (LAMBDA (FL RDTBL)
   (LIST 'NOT (READ FL RDTBL]
```

**SPLICE** The result (which should be a list or **NIL**) is spliced into the input using **NCONC**. For example, if **$** is defined by the read macro:

```
(SPLICE (LAMBDA NIL (APPEND FOO)))
```

and the value of **FOO** is **(A B C)**, then when the user inputs **(X $ Y)**, the result will be **(X A B C Y)**.

**INFIX** The associated function is called with a third argument, which is a list, in **TCONC** format (page 3.6), of what has been read at the current level of list nesting. The function's value is taken as a new **TCONC** list which replaces the old one. For example, the infix operator + could be defined by the read macro:

```
(INFIX (LAMBDA (FL RDTBL Z)
   (RPLACA (CDR Z)
    (LIST (QUOTE IPLUS)
```

```
        (CADR Z)
        (READ FL RDTBL)))
    Z))
```

If an **INFIX** read macro character is encountered *not* in a list, the third argument to its associated function is **NIL**. If the function returns **NIL**, the read macro character is essentially ignored and reading continues. Otherwise, if the function returns a **TCONC** list of one element, that element is the value of the **READ**. If it returns a **TCONC** list of more than one element, the list is the value of the **READ**.

The specification for a read macro character can be augmented to specify various options $OPTION_1$ ... $OPTION_N$, e.g., **(MACRO FIRST IMMEDIATE *FN*)**. The following three disjoint options specify when the read macro character is to be effective:

**ALWAYS** The default. The read macro character is always effective (except when preceded by the **%** character), and is a break character, i.e., a member of **(GETSYNTAX 'BREAK *RDTBL*)**.

**FIRST** The character is interpreted as a read macro character *only* when it is the first character seen after a break or separator character; in all other situations, the character is treated as having class **OTHER**. The read macro character is *not* a break character. For example, the quote character is a **FIRST** read macro character, so that **DON'T** is read as the single atom **DON'T**, rather than as **DON** followed by **(QUOTE T)**.

**ALONE** The read macro character is *not* a break character, and is interpreted as a read macro character only when the character would have been read as a separate atom if it were not a read macro character, i.e., when its immediate neighbors are both break or separator characters.

Making a **FIRST** or **ALONE** read macro character be a break character (with **SETBRK**) disables the read macro interpretation, i.e., converts it to syntax class **BREAKCHAR**. Making an **ALWAYS** read macro character be a break character is a no-op.

The following two disjoint options control whether the read macro character is to be protected by the **ESCAPE** character on output when a litatom containing the character is printed:

**ESCQUOTE** or **ESC** The default. When printed with **PRIN2**, the read macro character will be preceded by the output escape character (**%**) as needed to permit the atom containing it to be read correctly. Note that for **FIRST** macros, this means that the character need be quoted only when it is the first character of the atom.

**NOESCQUOTE** or **NOESC** The read macro character will always be printed without an escape. For example, the **?** read macro in the **T** read table is a **NOESCQUOTE** character. Unless you are very careful what you are doing, read macro characters in **FILERDTBL** should never be

**NOESCQUOTE**, since symbols that happen to contain the read macro character will not read back in correctly.

The following two disjoint options control when the macro's function is actually executed:

**IMMEDIATE** or **IMMED**

The read macro character is immediately activated, i.e., the current line is terminated, as if an **EOL** had been typed, a carriage-return line-feed is printed, and the entire line (including the macro character) is passed to the input function.

**IMMEDIATE** read macro characters enable the user to specify a character that will take effect immediately, as soon as it is encountered in the input, rather than waiting for the line to be terminated. Note that this is not necessarily as soon as the character is *typed*. Characters that cause action as soon as they are typed are interrupt characters (see page 30.1).

Note that since an **IMMEDIATE** macro causes any input before it to be sent to the reader, characters typed before an **IMMEDIATE** read macro character cannot be erased by control-A or control-Q once the **IMMEDIATE** character has been typed, since they have already passed through the line buffer. However, an **INFIX** read macro can still alter some of what has been typed earlier, via its third argument.

**NONIMMEDIATE** or **NONIMMED**

The default. The read macro character is a normal character with respect to the line buffering, and so will not be activated until a carriage-return or matching right parenthesis or bracket is seen.

Making a read macro character be both **ALONE** and **IMMEDIATE** is a contradiction, since **ALONE** requires that the next character be input in order to see if it is a break or separator character. Thus, **ALONE** read macros are always **NONIMMEDIATE**, regardless of whether or not **IMMEDIATE** is specified.

Read macro characters can be "nested". For example, if = is defined by

```
(MACRO (LAMBDA (FL RDTBL)
    (EVAL (READ FL RDTBL))))
```

and ! is defined by

```
(SPLICE (LAMBDA (FL RDTBL)
    (READ FL RDTBL)))
```

then if the value of **FOO** is **(A B C)**, and **(X = FOO Y)** is input, **(X (A B C) Y)** will be returned. If **(X ! = FOO Y)** is input, **(X A B C Y)** will be returned.

Note: If a read macro's function calls **READ**, and the **READ** returns **NIL**, the function cannot distinguish the case where a **RIGHTPAREN** or **RIGHTBRACKET** followed the read macro character, (e.g. "**(A B ')**"), from the case where the atom **NIL** (or "**()**") actually appeared. In Interlisp-D, a **READ** inside of a read macro when the next input character is a **RIGHTPAREN** or

**RIGHTBRACKET** reads the character and returns **NIL**, just as if the **READ** had not occurred inside a read macro.

If a call to **READ** from within a read macro encounters an unmatched **RIGHTBRACKET** *within* a list, the bracket is simply put back into the buffer to be read (again) at the higher level. Thus, inputting an expression such as **(A B '(C D]** works correctly.

**(INREADMACROP)** [Function]

Returns **NIL** if currently *not* under a read macro function, otherwise the number of unmatched left parentheses or brackets.

**(READMACROS** *FLG RDTBL***)** [Function]

If *FLG* = **NIL**, turns off action of read macros in read table *RDTBL*. If *FLG* = **T**, turns them on. Returns previous setting.

The following read macros are standardly defined in Interlisp in the **T** and **EDITRDTBL** read tables:

' (single-quote) Returns the next expression, wrapped in a call to **QUOTE**; e.g., **'FOO** reads as **(QUOTE FOO)**. The macro is defined as a **FIRST** read macro, so that the quote character has no effect in the middle of a symbol. The macro is also ignored if the quote character is immediately followed by a separator character.

control-Y Defined in **T** and **EDITRDTBL**. Returns the result of evaluating the next expression. For example, if the value of **FOO** is **(A B)**, then **(LIST 1** *control-Y***FOO 2)** is read as **(LIST 1 (A B) 2)**. Note that no structure is copied; the third element of that input expression is still **EQ** to the value of **FOO**. Control-Y can thus be used to read structures that ordinarily have no read syntax. For example, the value returned from reading **(KEY1** *control-Y***(ARRAY 10))** has an array as its second element. Control-Y can be thought of as an "un-quote" character. The choice of character to perform this function is changeable with **SETTERMCHARS** (page 16.75).

' (backquote) Backquote makes it easier to write programs to construct complex data structures. Backquote is like quote, except that within the backquoted expression, forms can be evaluated. The general idea is that the backquoted expression is a "template" containing some constant parts (as with a quoted form) and some parts to be filled in by evaluating something. Unlike with control-Y, however, the evaluation occurs not at the time the form is read, but at the time the backquoted expression is evaluated. That is, the backquote macro returns an expression which, when evaluated, produces the desired structure.

Within the backquoted expression, the character "," (comma) introduces a form to be evaluated. The value of a form preceded by ",@" is to be spliced in, using **APPEND**. If it is permissible to destroy the list being spliced in (i.e., **NCONC** may be used in the translation), then ",." can be used instead of ",@".

For example, if the value of **FOO** is **(1 2 3 4)**, then the form

**'(A ,(CAR FOO) ,@(CDDR FOO) D E)**

evaluates to **(A 1 3 4 D E)**; it is logically equivalent to writing

```
(CONS 'A
  (CONS (CAR FOO)
    (APPEND (CDDR FOO) '(D E))))
```

.

Backquote is particularly useful for writing macros. For example, the body of a macro that refers to **X** as the macro's argument list might be

```
'(COND
  ((FIXP ,(CAR X))
    ,(CADR X))
  (T .,(CDDR X)))
```

which is equivalent to writing

```
(LIST 'COND
   (LIST (LIST 'FIXP (CAR X))
      (CADR X))
   (CONS 'T (CDDR X)))
```

Note that comma does *not* have any special meaning outside of a backquote context.

For users without a backquote character on their keyboards, backquote can also be written as |' (vertical-bar, quote).

**?** Implements the **?=** command for on-line help regarding the function currently being "called" in the typein (see page 26.33).

| (vertical bar) When followed by an end of line, tab or space, | is ignored, i.e., treated as a separator character, enabling the editor's **CHANGECHAR** feature (page 26.49). Otherwise it is a "dispatching" read macro whose meaning depends on the character(s) following it. The following are currently defined:

' (quote) -- A synonym for backquote.

. (period) -- Returns the evaluation of the next expression, i.e., this is a synonym for control-Y.

**,** (comma) -- Returns the evaluation of the next expression *at load time*, i.e., the following expression is quoted in such a manner that the compiler treats it as a literal whose value is not determined until the compiled expression is loaded.

**O** or **o** (the letter O) -- Treats the next number as octal, i.e., reads it in radix 8. For example, **|o12 = 10** (decimal).

**B** or **b** -- Treats the next number as binary, i.e., reads it in radix 2. For example, **|b101 = 5** (decimal).

**X** or **x** -- Treats the next number as hexadecimal, i.e., reads it in radix 16. The upper-case letters **A** though **F** are used as the digits after **9**. For example, **|x1A = 26** (decimal).

**R** or **r** -- Reads the next number in the radix specified by the (decimal) number that appears between the **|** and the **R**. When inputting a number in a radix above ten, the upper-case letters **A** through **Z** can be used as the digits after **9** (but there is no digit above **Z**, so it is not possible to type all base-99 digits). For example, **|3r120** reads 120 in radix 3, returning 15.

**(**, **{**, **↑** -- Used internally by **HPRINT** and **HREAD** (page 25.17)to print and read unusual expressions.

The dispatching characters that are letters can appear in either upper or lower case.

# 26. USER INPUT/OUTPUT PACKAGES

This chapter presents a number of packages that have been developed for displaying and allowing the user to enter information. These packages are used to implement the user interface of many system facilities.

- The Inspector (below) provides a window-based facility for displaying and changing the fields of a data object.
- PROMPTFORWORD (page 26.9) is a function used for entering a simple string of characters. Basic editing and prompting facilities are provided.
- ASKUSER (page 26.12) provides a more complicated prompting and answering facility, allowing a series of questions to be printed. Prompts and argument completion are supported.
- TTYIN (page 26.22) is a display typein editor, that provides complex text editing facilities when entering an input line.
- PRETTYPRINT (page 26.40) is used for printing function definitions and other list structures, using multiple fonts and indenting lines to show the structure of the list.

## 26.1 Inspector

The Inspector provides a display-oriented facility for looking at and changing arbitrary Interlisp-D data structures. The inspector can be used to inspect all user datatypes and many system datatypes (although some objects such as numbers have no inspectable structure). The inspector displays the field names and values of an arbitrary object in a window that allows setting of the properties and further inspection of the values. This latter feature makes it possible to "walk" around all of the data structures in the system at the touch of a button. In addition, the inspector is integrated with the break package to allow inspection of any object on the stack and with the display and teletype structural editors to allow the editors to be used to "inspect" list structures and the inspector to "edit" datatypes.

The underlying mechanisms of the data inspector have been designed to allow their use as specialized editors in user applications. This functionality is described at the end of this section.

Note: Currently, the inspector does *not* have **UNDO**ing. Also, variables whose values are changed will not be marked as such.

### 26.1.1 Calling the Inspector

There are several ways to open an inspect window onto an object. In addition to calling **INSPECT** directly (below), the inspector can also be called by buttoning an **Inspect** command inside an existing inspector window. Finally, if a non-list is edited with **EDITDEF** (page 17.27), the inspector is called. This also causes the inspector to be called by the **Dedit** command from the display editor or the **EV** command from the teletype editor if the selected piece of structure is a non-list.

**(INSPECT** *OBJECT ASTYPE WHERE***)** [Function]

Creates an inspect window onto *OBJECT*. If *ASTYPE* is given, it will be taken as the record type of *OBJECT*. This allows records to be inspected with their property names. If *ASTYPE* is **NIL**, the data type of *OBJECT* will be used to determine its property names in the inspect window.

*WHERE* specifies the location of the inspect window. If *WHERE* is **NIL**, the user will be prompted for a location. If *WHERE* is a window, it will be used as the inspect window. If *WHERE* is a region, the inspect window will be created in that region of the screen. If *WHERE* is a position, the inspect window will have its lower left corner at that position on the screen.

**INSPECT** returns the inspect window onto *OBJECT*, or **NIL** if no inspection took place.

**(INSPECTCODE** *FN WHERE* **— — — —)** [Function]

Opens a window and displays the compiled code of the function *FN* using **PRINTCODE**. The window is scrollable.

*WHERE* determines where the window should appear. It can be a position, a region, or a window. If **NIL**, the user is prompted to specify the position of the window.

Note: If the Tedit library package is loaded, **INSPECTCODE** uses it to create the code inspector window. Also, if **INSPECTCODE** is called to inspect the frame name in a break window (page 14.3), the location in the code that the frame's PC indicates it was executing at the time is highlighted.

### 26.1.2 Multiple Ways of Inspecting

For some datatypes there is more than one aspect that is of interest or more than one method of inspecting the object. In these cases, the inspector will bring up a menu of the possibilities and wait for the user to select one.

If the object is a litatom, the commands are the types for which the litatom has definitions as determined by **HASDEF**. Some typical commands are:

**FNS** Edit the definition of the selected litatom.

**VARS** Inspect the value.

**PROPS** Inspect the property list.

If the object is a list, there will be choice of how to inspect the list:

**Inspect** Opens an inspect window in which the properties are numbers and the values are the elements of the list.

**TtyEdit** Calls the teletype list structure editor on the list (page 16.1).

**DisplayEdit** Calls the DEdit display editor on the list (page 16.1).

**As a PLIST** Inspects the list as a property list, if the list is in property list form: **((*$PROP_1$ $VAL_1$*) ... (*$PROP_N$ $VAL_N$*))**.

**As an ALIST** Inspects the list as an association-list, if the list is in **ASSOC** list form: **(*$PROP_1$ $VAL_1$ ... $PROP_N$ $VAL_N$*)**.

**As a record** Brings up a submenu with all of the **RECORD**s in the system and inspect the list with the one chosen.

**As a "record type"** Inspects the list as the record of the type named in its **CAR**, if the **CAR** of the list is the name of a **TYPERECORD** (page 8.7).

If the object is a bitmap, the choice is between inspecting the bitmap's contents with the bitmap editor (**EDITBM**) or inspecting the bitmap's fields.

Other datatypes may include multiple methods for inspecting objects of that type.

## 26.1.3 Inspect Windows

An inspect window displays two columns of values. The lefthand column lists the property names of the structure being inspected. The righthand column contains the values of the properties named on the left. For variable length data such as lists and arrays, the "property names" are numbers from 1 to the length of the inspected item and the values are the corresponding elements. For arrays, the property names are the array element numbers and the values are the corresponding elements of the array.

For large lists or arrays, or datatypes with many fields, the initial window may be too small to contain all of them. In these cases, the unseen elements can be scrolled into view (from the bottom) or the window can be reshaped to increase its size.

In an inspect window, the **LEFT** button is used to select things, the **MIDDLE** button to invoke commands that apply to the selected item. Any property or value can be selected by pointing the cursor directly at the text representing it, and clicking the **LEFT** button. There is one selected item per window and it is marked by having its surrounding box inverted.

The options offered by the **MIDDLE** button depend on whether the selection is a property or a value. If the selected item is a value, the options provide different ways of inspecting the selected structure. The exact commands that are given depend on the type of the value.

If the selected item is a property name, the command **SET** will appear. If selected, the user will be asked to type in an expression, and the selected property will be set to the result of evaluating the read form. The evaluation of the read form and the replacement of the selected item property will appear as their own history events and are individually undoable. Properties of system datatypes cannot be set. (There are often consistency requirements which can be inadvertently violated in ways that crash the system. This may be true of some user datatypes as well, however the system doesn't know which ones. Users are advised to exercise caution.)

It is possible to copy-select property names or values out of an inspect window. Litatoms, numbers and strings are copied as they are displayed. Unprintable objects (such as bitmaps, etc.) come out as an appropriate system expression, such that if is evaluated, the object is re-created.

## 26.1.4 Inspect Window Commands

By pressing the **MIDDLE** button in the title of the inspect window, a menu of commands that apply to the inspect window is brought up:

**ReFetch** [Inspect Window Command]

An inspect window is *not* automatically updated when the structure it is inspecting is changed. The "**ReFetch**" command will refetche and redisplay all of the fields of the object being inspected in the inspect window.

**IT←datum** [Inspect Window Command]

Sets the variable **IT** to object being inspected in the inspect window.

**IT←selection** [Inspect Window Command]

Sets the variable **IT** to the property name or value currently selected in the inspect window.

## 26.1.5 Interaction With Break Windows

The break window facility (page 14.3) knows about the inspector in the sense that the backtrace frame window is an inspect window onto the frame selected from the back trace menu during a break. Thus you can call the inspector on an object that is bound on the stack by selecting its frame in the back trace menu, selecting its value with the **LEFT** button in the back trace frame window, and selecting the inspect command with the **MIDDLE** button in the back trace frame window. The values of variables in frames can be set by selecting the variable name with the **LEFT** button and then the "**Set**" command with the **MIDDLE** button.

Note: The inspector will only allow the setting of named variables. Even with this restriction it is still possible to crash the system by setting variables inside system frames. Exercise caution in setting variables in other than your own code.

## 26.1.6 Controlling the Amount Displayed During Inspection

The amount of information displayed during inspection can be controlled using the following variables:

**MAXINSPECTCDRLEVEL** [Variable]

The inspector prints only the first **MAXINSPECTCDRLEVEL** elements of a long list, and will make the tail containing the unprinted elements the last item. The last item can be inspected to see further elements. Initially 50.

**MAXINSPECTARRAYLEVEL** [Variable]

The inspector prints only the first **MAXINSPECTARRAYLEVEL** elements of an array. The remaining elements can be inspected by calling the function **(INSPECT/ARRAY** *ARRAY BEGINOFFSET***)** which inspects the *BEGINOFFSET* through the *BEGINOFFSET* + **MAXINSPECTARRAYLEVEL** elements of *ARRAY*. Initially 300.

**INSPECTPRINTLEVEL** [Variable]

When printing the values, the inspector resets **PRINTLEVEL** (page 25.11) to the value of **INSPECTPRINTLEVEL**. Initially **(2 . 5)**.

**INSPECTALLFIELDSFLG** [Variable]

If **INSPECTALLFIELDSFLG** is **T**, the inspector will show computed fields (**ACCESSFNS**, page 8.12) as well as regular fields for structures that have a record definition. Initially **T**.

## 26.1.7 Inspect Macros

The Inspector can be extended to inspect new structures and datatypes by adding entries to the list **INSPECTMACROS**. An entry should be of the form (*OBJECTTYPE . INSPECTINFO*). *OBJECTTYPE* is used to determine the types of objects that are inspected with this macro. If *OBJECTTYPE* is a litatom, the *INSPECTINFO* will be used to inspect items whose type name is *OBJECTTYPE*. If *OBJECTTYPE* is a list of the form **(FUNCTION** *DATUM-PREDICATE*), *DATUM-PREDICATE* will be **APPLY**ed to the item and if it returns non-**NIL**, the *INSPECTINFO* will be used to inspect the item.

*INSPECTINFO* can be one of two forms. If *INSPECTINFO* is a litatom, it should be a function that will be applied to three arguments (the item being inspected, *OBJECTTYPE*, and the value of *WHERE* passed to **INSPECT**) that should do the inspection. If *INSPECTINFO* is not a litatom, it should be a list of (*PROPERTIES FETCHFN STOREFN PROPCOMMANDFN VALUECOMMANDFN TITLECOMMANDFN TITLE SELECTIONFN WHERE PROPPRINTFN*) where the elements of this list are the arguments for **INSPECTW.CREATE**, described below. From this list, the *WHERE* argument will be evaluated; the others will not. If *WHERE* is **NIL**, the value of *WHERE* that was passed to **INSPECT** will be used.

Examples:

The entry **((FUNCTION MYATOMP) PROPNAMES GETPROP PUTPROP)** on **INSPECTMACROS** would cause all objects satisfying the predicate **MYATOMP** to have their properties inspected with **GETPROP** and **PUTPROP**. In this example, **MYATOMP** should make sure the object is a litatom.

The entry **(MYDATATYPE . MYINSPECTFN)** on **INSPECTMACROS** would cause all datatypes of type **MYDATATYPE** to be passed to the function **MYINSPECTFN**.

## 26.1.8 INSPECTWs

The inspector is built on the abstraction of an **INSPECTW**. An **INSPECTW** is a window with certain window properties that display an object and respond to selections of the object's parts. It is characterized by an object and its list of properties. An **INSPECTW** displays the object in two columns with the property names on the left and the values of those properties on the right. An **INSPECTW** supports the protocol that the **LEFT** mouse button can be used to select any property name or property value and the **MIDDLE** button calls a user provided function on the selected value or property. For the Inspector application, this function puts up a menu of the alternative ways of inspecting values or of the ways of setting properties. **INSPECTWs** are created with the following function:

**(INSPECTW.CREATE** *DATUM PROPERTIES FETCHFN STOREFN PROPCOMMANDFN VALUECOMMANDFN TITLECOMMANDFN TITLE SELECTIONFN WHERE PROPPRINTFN***)** [Function]

Creates an **INSPECTW** that views the object *DATUM*. If *PROPERTIES* is a list, it is taken as the list of properties of *DATUM* to display. If *PROPERTIES* is a litatom, it is **APPLY**ed to *DATUM* and the result is used as the list of properties to display.

*FETCHFN* is a function of two arguments (*OBJECT PROPERTY*) that should return the value of the *PROPERTY* property of *OBJECT*. The result of this function will be printed (with **PRIN2**) in the **INSPECTW** as the value.

*STOREFN* is a function of three arguments (*OBJECT PROPERTY NEWVALUE*) that changes the *PROPERTY* property of *OBJECT* to *NEWVALUE*. It is used by the default *PROPCOMMANDFN* and *VALUECOMMANDFN* to change the value of a property and also by the function **INSPECTW.REPLACE** (described below). This can be **NIL** if the user provides command functions which do not call **INSPECTW.REPLACE**. Each replace action will be a separate event on the history list. Users are encouraged to provide **UNDO**able *STOREFN*s.

*PROPCOMMANDFN* is a function of three arguments (*PROPERTY OBJECT INSPECTW*) which gets called when the user presses the **MIDDLE** button and the selected item in the **INSPECTW** is a property name. *PROPERTY* will be the name of the selected property, *OBJECT* will be the datum being viewed, and *INSPECTW* will be the window. If *PROPCOMMANDFN* is a string, it will get printed in the **PROMPTWINDOW** when the **MIDDLE** button is pressed. This provides a convenient way to notify the user about disabled commands on the properties. **DEFAULT.INSPECTW.PROPCOMMANDFN**, the default *PROPCOMMANDFN*, will present a menu with the single command **Set** on it. If selected, the **Set** command will read a value from the user and set the selected property to the result of **EVAL**uating this read value.

*VALUECOMMANDFN* is a function of four arguments (*VALUE PROPERTY OBJECT INSPECTW*) that gets called when the user presses the **MIDDLE** button and the selected item in the

**INSPECTW** is a property value. *VALUE* will be the selected value (as returned by *FETCHFN*), *PROPERTY* will be the name of the property *VALUE* is the value of, *OBJECT* will be the datum being viewed, and *INSPECTW* will be the **INSPECTW** window. **DEFAULT.INSPECTW.VALUECOMMANDFN,** the default *VALUECOMMANDFN*, will present a menu of possible ways of inspecting the value and create a new Inspect window if one of the menu items is selected.

*TITLECOMMANDFN* is a function of two arguments (*INSPECTW OBJECT*) which gets called when the user presses the **MIDDLE** button and the cursor is in the title or border of the inspect window *INSPECTW*. This command function is provided so that users can implement commands that apply to the entire object. The default *TITLECOMMANDFN* (**DEFAULT.INSPECTW.TITLECOMMANDFN**) presents a menu with the commands **ReFetch, IT←datum,** and **IT←selection** (see page 26.4).

*TITLE* specifies the title of the window. If *TITLE* is **NIL**, the title of the window will be the printed form of *DATUM* followed by the string " Inspector". If *TITLE* is the litatom **DON'T**, the inspect window will not have a title. If *TITLE* is any other litatom, it will be applyed to the *DATUM* and the potential inspect window (if it is known). If this result is the litatom **DON'T**, the inspect window will not have a title; otherwise the result will be used as a title. If *TITLE* is not a litatom, it will be used as the title.

*SELECTIONFN* is a function of three arguments (*PROPERTY VALUEFLG INSPECTW*) which gets called when the user releases the left button and the cursor is on one of the items. The *SELECTIONFN* allows a program to take action on the user's selection of an item in the inspect window. At the time this function is called, the selected item has been "selected". The function **INSPECTW.SELECTITEM** (described below) can be used to turn off this selection. *PROPERTY* will be the name of the property of the selected item. *VALUEFLG* will be **NIL** if the selected item is the property name; **T** if the selected item is the property value.

*WHERE* indicates where the inspect window should go. Its interpretation is described in **INSPECT** (page 26.2).

*PROPPRINTFN* is a function of two arguments (*PROPERTY DATUM*) which gets called to determine what to print in the property place for the property *PROPERTY*. If *PROPPRINTFN* returns **NIL**, no property name will be printed and the value will be printed to the left of the other values.

An inspect window uses the following window property names to hold information: **DATUM, FETCHFN, STOREFN, PROPCOMMANDFN, VALUECOMMANDFN, SELECTIONFN,**

**PROPPRINTFN, INSPECTWTITLE, PROPERTIES, CURRENTITEM** and **SELECTABLEITEMS**.

**(INSPECTW.REDISPLAY** *INSPECTW PROPS —*) [Function]

Updates the display of the objects being inspected in *INSPECTW*. If *PROPS* is a property name or a list of property names, only those properties are updated. If *PROPS* is **NIL**, all properties are redisplayed. This function is provided because inspect windows do not automatically update their display when the object they are showing changes.

This function is called by the **ReFetch** command in the title command menu of an **INSPECTW** (page 26.4).

**(INSPECTW.REPLACE** *INSPECTW PROPERTY NEWVALUE*) [Function]

Calls the *STOREFN* of the inspect window *INSPECTW* to change the property named *PROPERTY* to the value *NEWVALUE* and updates the display of *PROPERTY*'s value in the display. This provides a functional interface for user *PROPCOMMANDFN*s.

**(INSPECTW.SELECTITEM** *INSPECTW PROPERTY VALUEFLG*) [Function]

Sets the selected item in an inspect window. The item is inverted on the display and put on the window property **CURRENTITEM** of *INSPECTW*. If *INSPECTW* has a **CURRENTITEM**, it is deselected. *PROPERTY* is the name of the property of the selected item. *VALUEFLG* is **NIL** if the selected item is the property name; **T** if the selected item is the property value. If *PROPERTY* is NIL, no item will be selected. This provides a way of deselecting all items.

## 26.2 PROMPTFORWORD

**PROMPTFORWORD** is a function that reads in a sequence of characters, generally from the keyboard, without involving **READ**-like syntax. A user can supply a prompting string, as well as a "candidate" string, which is printed and used if the user types only a word terminator character (or doesn't type anything before a given time limit). As soon as any characters are typed the "candidate" string is erased and the new input takes its place.

**PROMPTFORWORD** accepts user type-in until one of the "word terminator" characters is typed. Normally, the word terminator characters are **EOL, ESCAPE, LF, SPACE,** or **TAB**. This list can be changed using the *TERMINCHAR.LST* argument to

**PROMPTFORWORD**, for example if it is desirable to allow the user to input lines including spaces.

**PROMPTFORWORD** also recognizes the following special characters:

Control-A, Backspace, or DELETE — Any of these characters deletes the last character typed and appropriately erases it from the echo stream if it is a display stream.

Control-Q — Erases all the type-in so far.

Control-R — Reprints the accumulated string.

Control-V — "Quotes" the next character: after typing Control-V, the next character typed is added to the accumulated string, regardless of any special meaning it has. Allows the user to include editing characters and word terminator characters in the accumulated string.

Control-W — Erases the last word.

? — Calls up a "help" facility. The action taken is defined by the *GENERATE?LIST.FN* argument to **PROMPTFORWORD** (see below). Normally, this prints a list of possible candidates.

**(PROMPTFORWORD** *PROMPT.STR CANDIDATE.STR GENERATE?LIST.FN ECHO.CHANNEL DONTECHOTYPEIN.FLG URGENCY.OPTION TERMINCHARS.LST KEYBD.CHANNEL***)** [Function]

**PROMPTFORWORD** has a multiplicity of features, which are specified through a rather large number of input arguments, but the default settings for them (i.e., when they aren't given, or are given as **NIL**) is such to minimize the number needed in the average case, and an attempt has been made to order the more frequently non-defaulted arguments at the beginning of the argument list. The default input and echo are both to the terminal; the terminal table in effect during input allows most control characters to be **INDICATE**'d.

**PROMPTFORWORD** returns **NIL** if a null string is typed; this would occur when no candidate is given and only a terminator is typed, or when the candidate is erased and a terminator is typed with no other input still un-erased. In all other cases, **PROMPTFORWORD** returns a string.

**PROMPTFORWORD** is controlled through the following arguments:

*PROMPT.STR* — If non-**NIL**, this is coerced to a string and used for prompting; an additional space is output after this string.

*CANDIDATE.STR* — If non-**NIL**, this is coerced to a string and offered as initial contents of the input buffer.

*GENERATE?LIST.FN* — If non-**NIL**, this is either a string to be printed out for help, or a function to be applied to *PROMPT.STR* and *CANDIDATE.STR* (after both have been coerced to strings), and which should return a list of potential candidates. The help string or list of potential candidates will then be printed on a separate line, the prompt will be restarted, and any type-in will be re-echoed.

Note: If *GENERATE?LIST.FN* is a function, its value list will be cached so that it will be run at most once per call to **PROMPTFORWORD**.

*ECHO.CHANNEL* Coerced to an output stream; **NIL** defaults to **T**, the "terminal output stream", normally **(TTYDISPLAYSTREAM)**. To achieve echoing to the "current output stream", use **(GETSTREAM NIL 'OUTPUT)**. If echo is to a display stream, it will have a flashing caret showing where the next input is to be echoed.

*DONTECHOTYPEIN.FLG* If **T**, there is no echoing of the input characters. If the value of *DONTECHOTYPEIN.FLG* is a single-character atom or string, that character is echoed instead of the actual input. For example, **LOGIN** prompts for a password with *DONTECHOTYPEIN.FLG* being "*".

*URGENCY.OPTION* If **NIL**, **PROMPTFORWORD** quietly wait for input, as **READ** does; if a number, this is the number of seconds to wait for the user to respond (if timeout is reached, then *CANDIDATE.WORD* is returned, regardless of any other type-in activity); if **T**, this means to wait forever, but periodically flash the window to alert the user; if **TTY**, then **PROMPTFORWORD** grabs the TTY immediately. When *URGENCY.OPTION* = **TTY**, the cursor is temporarily changed to a different shape to indicate the urgent nature of the request.

*TERMINCHARS.LST* This is list of "word terminator" character codes; it defaults to **(CHARCODE (EOL ESCAPE LF SPACE TAB))**. This may also be a single character code.

*KEYBD.CHANNEL* If non-**NIL**, this is coerced to a stream, and the input bytes are taken from that stream. **NIL** defaults to the keyboard input stream. Note that this is *not* the same as the terminal input stream **T** (page 25.1), which is a *buffered* keyboard input stream, not suitable for use with **PROMPTFORWORD**.

Examples:

```
(PROMPTFORWORD
  "What is your FOO word?" 'Mumble
  (FUNCTION (LAMBDA () '(Grumble Bletch)))
  PROMPTWINDOW NIL 30)
```

This first prompts the user for input by printing the first argument as a prompt into **PROMPTWINDOW**; then the proffered default answer, "**Mumble**", is printed out and the caret starts flashing just after it to indicate that the upcoming input will be echoed there. If the user fails to complete a word within 30 seconds, then the result will be the string "**Mumble**".

```
(FRESHLINE T)
```

```
(LIST
  (PROMPTFORWORD
    (CONCAT "{" HOST "} Login:")
    (USERNAME NIL NIL T))
  (PROMPTFORWORD
    " (password)" NIL NIL NIL '*))
```

This first prompts in whatever window is currently **(TTYDISPLAYSTREAM)**, and then takes in a username; the second call prompts with " **(password)**" and takes in another word (the password) *without* proffering a candidate, echoing the typed-in characters as "*".

## 26.3 ASKUSER

DWIM, the compiler, the editor, and many other system packages all use **ASKUSER**, an extremely general user interaction package, for their interactions with the user at the terminal. **ASKUSER** takes as its principal argument *KEYLST* which is used to drive the interaction. *KEYLST* specifies what the user can type at any given point, how **ASKUSER** should respond to the various inputs, what value should be returned by **ASKUSER**, and is also used to present the user at any given point with a list of the possible responses. **ASKUSER** also takes other arguments which permit specifying a wait time, a default value, a message to be printed on entry, a flag indicating whether or not typeahead is to be permitted, a flag indicating whether the transaction is to be stored on the history list (page 13.1), a default set of options, and an (optional) input file/string.

**(ASKUSER** *WAIT DEFAULT MESS KEYLST TYPEAHEAD LISPXPRNTFLG OPTIONSLST FILE*) [Function]

*WAIT* is either **NIL** or a number (of seconds). *DEFAULT* is a single character or a sequence (list) of characters to be used as the default inputs for the case when *WAIT* is not **NIL** and more than *WAIT* seconds elapse without any input. In this case, the character(s) from *DEFAULT* are processed exactly as though they had been typed, except that **ASKUSER** first types "...".

*MESS* is the initial message to be printed by **ASKUSER**, if any, and can be a string, or a list. In the latter case, each element of the list is printed, separated by spaces, and terminated with a " ? ". *KEYLST* and *OPTIONSLST* are described. *TYPEAHEAD* is **T** if the user is permitted to typeahead a response to **ASKUSER**. **NIL** means any typeahead should be cleared and saved. *LISPXPRNTFLG* determines whether or not the interaction is to be recorded on the history list. *FILE* can be either **NIL** (in which case it defaults to the terminal input stream, **T**), a stream, or a string. If *FILE* is a string, and all of its characters are read before **ASKUSER** finishes, *FILE* will be reset to **T**, and the interaction will continue with **ASKUSER** reading from the terminal.

All input operations take place from *FILE* until an unacceptable input is encountered, i.e., one that does not conform to the protocol defined by *KEYLST*. At that point, *FILE* is set to **T**, *DEFAULT* is set to **NIL**, the input buffer is cleared, and a bell is rung. Unacceptable inputs are not echoed.

The value of **ASKUSER** is the result of packing all the keys that were matched, unless the **RETURN** option is specified (page 26.15).

**(MAKEKEYLST** *LST DEFAULTKEY LCASEFLG AUTOCOMPLETEFLG***)** [Function]

*LST* is a list of atoms or strings. **MAKEKEYLST** returns an **ASKUSER** *KEYLST* which will permit the user to specify one of the elements on *LST* by either typing enough characters to make the choice unambiguous, or else typing a number between 1 and *N*, where *N* is the length of *LST*.

For example, if **ASKUSER** is called with *KEYLST* = **(MAKEKEYLST '(CONNECT SUPPORT COMPILE))**, then the user can type **C-O-N**, **S**, **C-O-M**, **1**, **2**, or **3** to indicate one of the three choices.

If *LCASEFLG* = **T**, then echoing of upper case elements will be in lower case (but the value returned will still be one of the elements of *LST*). If *DEFAULTKEY* is non-**NIL**, it will be the last key on the *KEYLST*. Otherwise, a key which permits the user to indicate "No - none of the above" choices, in which case the value returned by **ASKUSER** will be **NIL**.

*AUTOCOMPLETEFLG* is used as the value of the **AUTOCOMPLETEFLG** option of the resulting key list.

## 26.3.1 Format of KEYLST

*KEYLST* is a list of elements of the form (*KEY PROMPTSTRING* . *OPTIONS*), where *KEY* is an atom or a string (equivalent), *PROMPTSTRING* is an atom or a string, and *OPTIONS* a list of options in property list format. The options are explained below. If an option is specified in *OPTIONS*, the value of the option is the next element. Otherwise, if the option is specified in the *OPTIONSLST* argument to **ASKUSER**, its value is the next element on *OPTIONSLST*. Thus, *OPTIONSLST* can be used to provide default options for an entire *KEYLST*, rather than having to include the option at each level. If an option does not appear on either *OPTIONS* or *OPTIONSLST*, its value is **NIL**.

For convenience, an entry on *KEYLST* of the form (*KEY* . *ATOM/STRING*), can be used as an abbreviation for (*KEY*

*ATOM/STRING* **CONFIRMFLG T)**, and an entry of just the form *KEY*, i.e., a non-list, as an abbreviation for (*KEY* **NIL CONFIRMFLG T)**.

As each character is read, it is matched against the currently active keys. A character matches a key if it is the same character as that in the corresponding position in the key, or, if the character is an alphabetic character, if the characters are the same without regard for upper/lower case differences, i.e. "**A**" matches "**a**" and vice versa (unless the **NOCASEFLG** option is **T**, see page 26.15). In other words, if two characters have already been input and matched, the third character is matched with each active key by comparing it with the third character of that key. If the character matches with one or more of the keys, the entries on *KEYLST* corresponding to the remaining keys are discarded. If the character does not match with any of the keys, the character is not echoed, and a bell is rung instead.

When a key is complete, *PROMPTSTRING* is printed (**NIL** is equivalent to "", the empty string, i.e., nothing will be printed). Then, if the value of the **CONFIRMFLG** option is **T**, **ASKUSER** waits for confirmation of the key by a carriage return or space. Otherwise, the key does not require confirmation.

Then, if the value of the **KEYLST** option is not **NIL**, its value becomes the new *KEYLST*, and the process recurses. Otherwise, the key is a "leaf," i.e., it terminates a particular path through the original, top-level *KEYLST*, and **ASKUSER** returns the result of packing all the keys that have been matched and completed along the way (unless the **RETURN** option is used to specify some other value, as described below).

For example, when **ASKUSER** is called with *KEYLST* = **NIL**, the following *KEYLST* is used as the default:

**((Y "es$^{cr}$") (N "o$^{cr}$"))**

This *KEYLST* specifies that if (as soon as) the user types **Y** (or **y**), **ASKUSER** echoes with **Y**, prompts with "**es$^{cr}$**", and returns **Y** as its value. Similarly, if the user types **N**, **ASKUSER** echoes the **N**, prompts with "**o$^{cr}$**", and returns **N**. If the user types ?, **ASKUSER** prints:

**Yes**
**No**

to indicate his possible responses. All other inputs are unacceptable, and **ASKUSER** will ring the bell and not echo or print anything.

For a more complicated example, the following is the *KEYLST* used for the compiler questions (page 18.1):

**((ST "ore and redefine " KEYLST ("" (F . "orget exprs"))**
**(S . "ame as last time")**

**(F . "File only")**
**(T . "o terminal")**
**1**
**2**
**(Y . "es")**
**(N . "o"))**

When **ASKUSER** is called with this *KEYLST*, and the user types an **S**, two keys are matched: **ST** and **S**. The user can then type a **T**, which matches only the **ST** key, or confirm the **S** key by typing a $^{cr}$ or space. If the user confirms the **S** key, **ASKUSER** prompts with "**ame as last time**", and returns **S** as its value. (Note that the confirming character is not included in the value.) If the user types a **T, ASKUSER** prompts with "**ore and redefine**", and makes **("" (F . "orget exprs"))** be the new *KEYLST*, and waits for more input. The user can then type an **F**, or confirm the "" (which essentially starts out with all of its characters matched). If he confirms the "", **ASKUSER** returns **ST** as its value the result of packing **ST** and "". If he types **F, ASKUSER** prompts with "**orget exprs**", and waits for confirmation again. If the user then confirms, **ASKUSER** returns **STF**, the result of packing **ST** and **F**.

At any point the user can type a **?** and be prompted with the possible responses. For example, if the user types **S** and then **?**, **ASKUSER** will type:

**STore and redefine Forget exprs**
**STore and redefine**
**Same as last time**

## 26.3.2 Options

**KEYLST** When a key is complete, if the value of the **KEYLST** option is not **NIL**, this value becomes the new *KEYLST* and the process recurses. Otherwise, the key terminates a path through the original, top-level *KEYLST*, and **ASKUSER** returns the indicated value.

**CONFIRMFLG** If **T**, the key must be confirmed with either a carriage return or a space. If the value of **CONFIRMFLG** is a *list*, the confirming character may be any member of the list.

**PROMPTCONFIRMFLG** If **T**, whenever confirmation is required, the user is prompted with the string " **[confirm]** ".

**NOCASEFLG** If **T**, says do *not* perform case independent matching on alphabetic characters. If **NIL**, do perform case independent matching, i.e. "**A**" matches with "**a**" and vice versa.

**RETURN** If non-**NIL, EVAL** of the value of the **RETURN** option is returned as the value of **ASKUSER**. Note that different **RETURN** options can be specified for different keys. The variable **ANSWER** is bound in **ASKUSER** to the list of keys that have been matched. In other words, **RETURN (PACK ANSWER)** would be equivalent to what **ASKUSER** normally does.

**NOECHOFLG** If non-**NIL**, characters that are matched (or automatically supplied as a result of typing **$** (escape) or confirming) are not echoed, nor is the confirming character, if any. The value of **NOECHOFLG** is automatically **NIL** when **ASKUSER** is reading from a file or string. The decision about whether or not to echo a character that matches several keys is determined by the value of the **NOECHOFLG** option for the first key.

**EXPLAINSTRING** If the value of the **EXPLAINSTRING** option is non-**NIL**, its value is printed when the user types a **?**, rather than *KEY* + *PROMPTSTRING*. **EXPLAINSTRING** enables more elaborate explanations in response to a **?** than what the user sees when he is prompted as a result of simply completing keys.

For example: One of the entries on the *KEYLST* used by **ADDTOFILES?** (page 17.13) is:

**(] "Nowhere$^{cr}$" NOECHOFLG T**
**EXPLAINSTRING "] - nowhere, item is marked as a dummy$^{cr}$")**

When the user types **]**, **ASKUSER** just prints "**Nowhere$^{cr}$**", i.e., the **]** is not echoed. If the user types **?**, the explanation corresponding to this entry will be:

**] - nowhere, item is marked as a dummy**

**KEYSTRING** If non-**NIL**, characters that are matched are echoed as though the value of **KEYSTRING** were used in place of the key. **KEYSTRING** is also used for computing the value returned. The main reason for this feature is to enable echoing in lowercase.

**PROMPTON** If non-**NIL**, *PROMPTSTRING* is printed *only* when the key is confirmed with a member of the value of **PROMPTON**.

**COMPLETEON** When a confirming character is typed, the *N* characters that are automatically supplied, as specified in case (4), are echoed *only* when the key is confirmed with a member of the value of **PROMPTON**.

The **PROMPTON** and **COMPLETEON** options enable the user to construct a *KEYLST* which will cause **ASKUSER** to emulate the action of the TENEX exec. The protocol followed by the TENEX exec is that the user can type as many characters as he likes in specifying a command. The command can be completed with a carriage return or space, in which case no further output is forthcoming, or with a **$** (escape), in which case the rest of the characters in the command are echoed, followed by some prompting information. The following *KEYLST* would handle the TENEX **COPY** and **CONNECT** comands:

```
((COPY " (FILE LIST) "
        PROMPTON ($)
```

```
            COMPLETEON ($)
            CONFIRMFLG ($))
(CONNECT " (TO DIRECTORY) "
            PROMPTON ($)
            COMPLETEON ($)
            CONFIRMFLG ($)))
```

**AUTOCOMPLETEFLG** If the value of the **AUTOCOMPLETEFLG** option is not **NIL**, **ASKUSER** will automatically supply unambiguous characters whenever it can, i.e., **ASKUSER** acts as though **$** (escape) were typed after each character (except that it does not ring the bell if there are no unambiguous characters).

**MACROCHARS** value is a list of dotted pairs of form **(***CHARACTER* . *FORM***)**. When *CHARACTER* is typed, and it does not match any of the current keys, *FORM* is evaluated and nothing else happens, i.e. the matching process stays where it is. For example, **?** could have been implemented using this option. Essentially **MACROCHARS** provides a read macro facility while inside of **ASKUSER** (since **ASKUSER** does **READC**'s, read macros defined via the readtable are never invoked).

**EXPLAINDELIMITER** value is what is printed to delimit explanation in response to ?. Initially a carriage return, but can be reset, e.g. to a comma, for more linear output.

## 26.3.3 Operation

All input operations are executed with the terminal table in the variable **ASKUSERTTBL**, in which (1) **(CONTROL T)** has been executed (see page 30.10), so that **ASKUSER** can interact with the user after each character is typed; and (2) **(ECHOMODE NIL)** has been executed (see page 30.7), so that **ASKUSER** can decide *after* it reads a character whether or not the character should be echoed, and with what, e.g. unacceptable inputs are never echoed.

As each character is typed, it is matched against *KEYLST*, and appropriate echoing and/or prompting is performed. If the user types an unacceptable character, **ASKUSER** simply rings the bell and allows him to try again.

At any point, the user can type **?** and receive a list of acceptable responses at that point (generated from *KEYLST*), or type a control-A, control-Q, control-X, or delete, which causes **ASKUSER** to reinitialize, and start over.

Note that **?**, Control-A, Control-Q, and Control-X will not work if they are acceptable inputs, i.e., they match one of the keys on *KEYLST*. Delete will not work if it is an interrupt character, in which case it is not seen by **ASKUSER**.

When an acceptable sequence is completed, **ASKUSER** returns the indicated value.

## 26.3.4 Completing a Key

The decision about when a key is complete is more complicated than simply whether or not all of its characters have been matched. In the compiler questions example above, all of the characters in the **S** key are matched as soon as the **S** has been typed, but until the next character is typed, **ASKUSER** does not know whether the **S** completes the **S** key, or is simply the first character in the **ST** key. Therefore, a key is considered to be complete when:

(1) All of its characters have been matched and it is the only key left, i.e., there are no other keys for which this key is a substring.

(2) All of its characters have been matched and a confirming character is typed.

(3) All of its characters have been matched, and the value of the **CONFIRMFLG** option is **NIL**, and the value of the **KEYLST** option is not **NIL**, and the next character matches one of the keys on the value of the **KEYLST** option.

(4) There is only one key left and a confirming character is typed. Note that if the value of **CONFIRMFLG** is **T**, the key still has to be confirmed, regardless of whether or not it is complete. For example, if the first entry in the above example were instead

**(ST "ore and redefine " CONFIRMFLG T KEYLST ("" (F . "orget exprs"))**

and the user wanted to specify the **STF** path, he would have to type **ST**, *then* confirm before typing **F**, even though the **ST** completed the **ST** key by the rule in case (1). However, he would be prompted with "**ore and redefine**" as soon as he typed the **T**, and completed the **ST** key.

Case (2) says that confirmation can be used to complete a key in the case where it is a substring of another key, even where the value of **CONFIRMFLG** is **NIL**. In this case, the confirming character doubles as both an indicator that the key is complete, and also to confirm it, if necessary. This situation corresponds to typing **S**$^{cr}$ in the above example.

Case (3) says that if there were another entry whose key was **STX** in the above example, so that after the user typed **ST**, two keys, **ST** and **STX**, were still active, then typing **F** would complete the **ST** key, because **F** matches the **(F . "orget exprs")** entry on the value of the **KEYLST** option of the **ST** entry. In this case, "**ore and redefine**" would be printed *before* the **F** was echoed.

Finally, case (4) says that the user can use confirmation to specify completion when only one key is left, even when all of its characters have not been matched. For example, if the first key in the above example were **STORE**, the user could type **ST** and then confirm, and **ORE** would be echoed, followed by whatever prompting was specified. In this case, the confirming character also confirms the key if necessary, so that no further action is required, even when the value of **CONFIRMFLG** is **T**.

Case (4) permits the user not to have to type every character in a key when the key is the only one left. Even when there are several active keys, the user can type **$** (escape) to specify the next $N>0$ common characters among the currently active keys. The effect is exactly the same as though these characters had been typed. If there are no common characters in the active keys at that point, i.e. $N=0$, the **$** is treated as an incorrect input, and the bell is rung. For example, if *KEYLST* is **(CLISPFLG CLISPIFYPACKFLG CLISPIFTRANFLG)**, and the user types **C** followed by **$**, **ASKUSER** will supply the **L**, **I**, **S**, and **P**. The user can then type **F** followed by a carriage return or space to complete and confirm **CLISPFLG**, as per case (4), or type **I**, followed by **$**, and **ASKUSER** will supply the **F**, etc. Note that the characters supplied do not have to correspond to a terminal segment of any of the keys. Note also that the **$** does not confirm the key, although it may complete it in the case that there is only one key active.

If the user types a confirming character when several keys are left, the next $N>0$ common characters are still supplied, the same as with **$**. However, **ASKUSER** assumes the intent was to complete a key, i.e., case (4) is being invoked. Therefore, after supplying the next *N* characters, the bell is rung to indicate that the operation was not completed. In other words, typing a confirming character has the same effect as typing an **$** in that the next *N* common characters are supplied. Then, if there is only one key left, the key is complete (case 4) and confirmation is not required. If the key is not the only key left, the bell is rung.

## 26.3.5 Special Keys

**&** This can be used as a key to match with any single character, provided the character does not match with some other key at that level. For the purposes of echoing and returning a value, the effect is the same as though the character that were matched actually appeared as the key.

**$** (escape) This can be used as a key to match with the result of a single call to **READ**. For example, if the *KEYLST* were:

```
((COPY " (FILE LIST) "
        PROMPTON ($)
```

**COMPLETEON ($)**
**CONFIRMFLG ($)**
**KEYLST (($ NIL RETURN ANSWER)))**

then if the user typed **COP FOO**$^{cr}$, **(COPY FOO)** would be returned as the value of **ASKUSER**. One advantage of using **$**, rather than having the calling program perform the **READ**, is that the call to **READ** from inside **ASKUSER** is **ERRORSET** protected, so that the user can back out of this path and reinitialize **ASKUSER**, e.g. to change from a **COPY** command to a **CONNECT** command, simply by typing control-E.

**$$** (escape, escape) This can be used as a key to match with the result of a single call to **READLINE**.

A list A list can be used as a key, in which case the list/form is evaluated and its value "matches" the key. This feature is provided primarily as an escape hatch for including arbitrary input operations as part of an **ASKUSER** sequence. For example, the effect of **$$** (escape, escape) could be achieved simply by using **(READLINE T)** as a key.

**""** The empty string can be used as a key. Since it has no characters, all of its characters are automatically matched. "" essentially functions as a place marker. For example, one of the entries on the *KEYLST* used by **ADDTOFILES?** is:

```
("" "File/list: "
   EXPLAINSTRING "a file name or name of a function list"
   KEYLST ($))
```

Thus, if the user types a character that does not match any of the other keys on the *KEYLST*, then the character completes the "" key, by virtue of case (4), since the character *will* match with the **$** in the inner *KEYLST*. **ASKUSER** then prints "File/list: " *before* echoing the character, then calls **READ**. The character will be read as part of the **READ**. The value returned by **ASKUSER** will be the value of the **READ**.

Note: For **$** (escape), **$$** (escape, escape), or a list, if the last character read by the input operation is a separator, the character is treated as a confirming character for the key. However, if the last character is a break character, it will be matched against the next key.

## 26.3.6 Startup Protocol and Typeahead

Interlisp permits and encourages the user to typeahead; in actual practice, the user frequently does this. This presents a problem for **ASKUSER**. When **ASKUSER** is entered and there has been typeahead, was the input intended for **ASKUSER**, or was the interaction unanticipated, and the user simply typing ahead to some other program, e.g. the programmer's assistant? Even where there was no typeahead, i.e., the user starts typing *after* the call to **ASKUSER**, the question remains of whether the user had time to see the message from **ASKUSER** and react to it, or simply began typing ahead at an inauspicious moment. Thus, what is needed is an interlock mechanism which warns the user to stop typing, gives him a chance to respond to the warning, and then allows him to begin typing to **ASKUSER**.

Therefore, when **ASKUSER** is first entered, and the interaction is to take place with a terminal, and typeahead to **ASKUSER** is not permitted, the following protocol is observed:

(1) If there is typeahead, **ASKUSER** clears and saves the input buffers and rings the bell to warn the user to stop typing. The buffers will be restored when **ASKUSER** completes operation and returns.

(2) If *MESS*, the message to be printed on entry, is not **NIL** (the typical case), **ASKUSER** then prints *MESS* if it is a string, otherwise **CAR** of *MESS*, if *MESS* is a list.

(3) After printing *MESS* or **CAR** of *MESS*, **ASKUSER** waits until the output has actually been printed on the terminal to make sure that the user has actually had a chance to see the output. This also give the user a chance to react. **ASKUSER** then checks to see if anything additional has been typed in the intervening period since it first warned the user in (1). If something has been typed, **ASKUSER** clears it out and again rings the bell. This latter material, i.e., that typed between the entry to **ASKUSER** and this point, is discarded and will not be restored since it is not certain whether the user simply reacted quickly to the first warning (bell) and this input is intended for **ASKUSER**, or whether the user was in the process of typing ahead when the call to **ASKUSER** occurred, and did not stop typing at the first warning, and therefore this input is a continuation of input intended for another program.

Anything typed after (3) is considered to be intended for **ASKUSER**, i.e., once the user sees *MESS* or **CAR** of *MESS*, he is free to respond. For example, **UNDO** (page 13.13) calls **ASKUSER** when the number of undosaves are exceeded for an event with *MESS* = **(LIST** *NUMBER-UNDOSAVES* **"undosaves, continue saving")**. Thus, the user can type a response as soon as *NUMBER-UNDOSAVES* is typed.

(4) **ASKUSER** then types the rest of *MESS*, if any.

(5) Then **ASKUSER** goes into a wait loop until something is typed. If *WAIT*, the wait time, is not **NIL**, and nothing is typed in *WAIT* seconds, **ASKUSER** will type "..." and treat the elements of *DEFAULT*, the default value, as a list of characters, and begin processing them exactly as though they had been typed. If the user does type anything within *WAIT* seconds, he can then wait

as long as he likes, i.e., once something has been typed, **ASKUSER** will not use the default value specified in *DEFAULT*.

If the user wants to consider his response for more than *WAIT* seconds, and does not want **ASKUSER** to default, he can type a carriage return or a space, which are ignored if they are not specified as acceptable inputs by *KEYLST* (see below) and they are the first thing typed.

If the calling program knows that the user is expecting an interaction with **ASKUSER**, e.g. another interaction preceded this one, it can specify in the call to **ASKUSER** that typeahead is permitted. In this case, **ASKUSER** simply notes whether there is any typeahead, then prints *MESS* and goes into a wait loop as described above.

If there is typeahead that contains unacceptable input, **ASKUSER** will assume that the typeahead was not intended for **ASKUSER**, and will restore the typeahead when it completes operation and returns.

(6) Finally, if the interaction is not with the terminal, i.e., the optional input file/string is specified, **ASKUSER** simply prints *MESS* and begins reading from the file/string.

## 26.4 TTYIN Display Typein Editor

TTYIN is an Interlisp function for reading input from the terminal. It features altmode completion, spelling correction, help facility, and fancy editing, and can also serve as a glorified free text input function. This document is divided into two major sections: how to use TTYIN from the user's point of view, and from the programmer's.

TTYIN exists in implementations for Interlisp-10 and Interlisp-D. The two are substantially compatible, but the capabilities of the two systems differ (Interlisp-D has a more powerful display and allows greater access to the system primitives needed to control it effectively; it also has a mouse, greatly reducing the need for keyboard-oriented editing commands). Descriptions of both are included in this document for completeness, but Interlisp-D users may find large sections irrelevant.

### 26.4.1 Entering Input With TTYIN

There are two major ways of using TTYIN: (1) set **LISPXREADFN** to **TTYIN**, so the LISPX executive uses it to obtain input, and (2) call **TTYIN** from within a program to gather text input. Mostly the same rules apply to both; places where it makes a difference are mentioned below.

The following characters may be used to edit your input, independent of what kind of terminal you are on. The more TTYIN knows about your terminal, of course, the nicer some of these will behave. Some functions are performed by one of several characters; any character that you happen to have assigned as an interrupt character will, of couse, not be read by TTYIN. There is a (somewhat inelegant) way of changing which characters perform which functions, described under **TTYINREADMACROS** later on.

control-A, Backspace, Delete — Deletes a character. At the start of the second or subsequent lines of your input, deletes the last character of the previous line.

control-W — Deletes a "word". Generally this means back to the last space or parenthesis.

control-Q — Deletes the current line, or if the current line is blank, deletes the previous line.

control-R — Refreshes the current line. Two in a row refreshes the whole buffer (when doing multi-line input).

Escape — Tries to complete the current word from the spelling list provided to **TTYIN**, if any. In the case of ambiguity, completes as far as is uniquely determined, or rings the bell. For **LISPX** input, the spelling list may be **USERWORDS** (see discussion of **TTYINCOMPLETEFLG**, page 26.37).

Interlisp-10 only: If no spelling list was provided, but the word begins with a "<", tries directory name completion (or filename completion if there is already a matching ">" in the current word).

? — If typed in the middle of a word will supply alternative completions from the *SPLST* argument to **TTYIN** (if any). **?ACTIVATEFLG** (page 26.36) must be true to enable this feature.

control-F — Tops20 only: Invokes filename completion on the current "word".

control-Y — Escapes to a Lisp user exec, from which you may return by the command **OK**. However, when in READ mode and the buffer is non-empty, control-Y is treated as Lisp's unquote macro instead, so you have to use meta-control-Y (below) to invoke the user exec.

Open key on Xerox 1132
Middle-blank key on Xerox 1132
LF in Interlisp-10 — Retrieves characters from the previous non-empty buffer when it is able to; e.g., when typed at the beginning of the line this command restores the previous line you typed at TTYIN; when typed in the middle of a line fills in the remaining text from the

old line; when typed following ↑Q or ↑W restores what those commands erased.

; If typed as the first character of the line means the line is a comment; it is ignored, and TTYIN loops back for more input.

Note: The exact behaviour of this character is determined by the value of **TTYINCOMMENTCHAR** (page 26.37).

control-X Goes to the end of your input (or end of expression if there is an excess right parenthesis) and returns if parentheses are balanced, beeps if not. Currently implemented in Interlisp-D only.

During most kinds of input, TTYIN is in "autofill" mode: if a space is typed near the right margin, a carriage return is simulated to start a new line. In fact, on cursor-addressable displays, lines are always broken, if possible, so that no word straddles the end of the line. The "pseudo-carriage return" ending the line is still read as a space, however; i.e., the program keeps track of whether a line ends in a carriage return or is merely broken at some convenient point. You won't get carriage returns in your strings unless you explicitly type them.

## 26.4.2 Mouse Commands [Interlisp-D Only]

The mouse buttons are interpreted as follows during TTYIN input:

**LEFT** Moves the caret to where the cursor is pointing. As you hold down **LEFT**, the caret moves around with the cursor; after you let up, any typein will be inserted at the new position.

**MIDDLE** Like **LEFT**, but moves only to word boundaries.

**RIGHT** Deletes text from the caret to the cursor, either forward or backward. While you hold down **RIGHT**, the text to be deleted is complemented; when you let up, the text actually goes away. If you let up outside the scope of the text, nothing is killed (this is how to "cancel" the command). This is roughly the same as **CTRL-RIGHT** with no initial selection (below).

If you hold down **CTRL** and/or **SHIFT** while pressing the mouse buttons, you instead get secondary selection, move selection or delete selection. You make a selection by bugging **LEFT** (to select a character) or **MIDDLE** (to select a word), and optionally extend the selection either left or right using **RIGHT**. While you are doing this, the caret does not move, but your selected text is highlighted in a manner indicating what is about to happen. When you have made your selection (all mouse buttons up now), lift up on **CTRL** and/or **SHIFT** and the action you have selected will occur, which is:

**SHIFT** The selected text as typein at the caret. The text is highlighted with a broken underline during selection.

**CTRL** Delete the selected text. The text is complemented during selection.

**CTRL-SHIFT** Combines the above: delete the selected text and insert it at the caret. This is how you move text about.

You can cancel a selection in progress by pressing **LEFT** or **MIDDLE** as if to select, and moving outside the range of the text.

The most recent text deleted by mouse command can be inserted at the caret by typing Middle-blank key (on the Xerox 1132) or the Open key (on the Xerox 1108). This is the same key that retrieves the previous buffer when issued at the end of a line.

## 26.4.3 Display Editing Commands

On terminals with a meta key: In Interlisp-10, TTYIN reads from the terminal in binary mode, allowing many more editing commands via the meta key, in the style of TVEDIT commands. Note that due to Tenex's unfortunate way of handling typeahead, it is not possible to type ahead edit commands before TTYIN has started (i.e., before its prompt appears), because the meta bit will be thrown away. Also, since Escape has numerous other meanings in Lisp and even in TTYIN (for completion), this is not used as a substitute for the meta key.

In Interlisp-D: Users will probably have little use for most of these commands, as cursor positioning can often be done more conveniently, and certainly more obviously, with the mouse. Nevertheless, some commands, such as the case changing commands, can be useful. The <bottom-blank> key can be used as an meta key if you perform **(METASHIFT T)** (see page 30.22). Alternatively, you can use the variable **EDITPREFIXCHAR** as described in the next paragraph.

On display terminals without a meta key: If you want to type any of these commands, you need to prefix them with the "edit prefix" character. Set the variable **EDITPREFIXCHAR** to the character code of the desired prefix char. Type the edit prefix twice to give an "meta-escape" command. Some users of the TENEX TVEDIT program like to make escape (33Q) be the edit prefix, but this makes it somewhat awkward to ever use escape completion. **EDITPREFIXCHAR** is initially **NIL**.

On hardcopy terminals without a meta key: You probably want to ignore this section, since you won't be able to see what's going on when you issure edit commands; there is no attempt made to echo anything reasonable.

In the descriptions below, "current word" means the word the cursor is under, or if under a space, the previous word. Currently parentheses are treated as spaces, which is usually what you want, but can occasionally cause confusion in the word deletion commands. The notation [*CHAR*] means meta-*CHAR*, if you have a meta key, or *CHAR* preceeded by the character number **EDITPREFIXCHAR** if you don't. The notation $ stands for the Escape key. Most commands can be preceded by numbers or escape (means infinity), only the first of which requires the meta key (or the edit prefix). Some commands also accept negative arguments, but some only look at the magnitude of the arg. Most of these commands are taken from the display editors TVEDIT and/or E, and are confined to work within one line of text unless otherwise noted.

Cursor Movement Commands:

| | |
|---|---|
| [delete], [bs], [<] | Back up one (or n) characters. |
| [space], [>] | Move forward one (or n) characters. |
| [↑] | Moves up one (or n) lines. |
| [lf] | Moves down one (or n) lines. |
| [(] | Move back one (or n) words. |
| [)] | Move ahead one (or n) words. |
| [tab] | Moves to end of line; with an argument moves to nth end of line; [$tab] goes to end of buffer. |
| [control-L] | Moves to start of line (or nth previous, or start of buffer). |
| [{] and [}] | Go to start and end of buffer, respectively (like [$control-L] and [$tab]). |
| [ [ ] (meta-left-bracket) | Moves to beginning of the current list, where cursor is currently under an element of that list or its closing paren. (See also the auto-parenthesis-matching feature below under "Flags".) |
| [ ] ] (meta-right-bracket) | Moves to end of current list. |
| [Sx] | Skips ahead to next (or nth) occurrence of character x, or rings the bell. |
| [Bx] | Backward search, i.e., short for [-S] or [-nS]. |

Buffer Modification Commands:

| | |
|---|---|
| [Zx] | Zaps characters from cursor to next (or nth) occurrence of x. There is no unzap command yet. |
| [A] or [R] | Repeat the last S, B or Z command, regardless of any intervening input (note this differs from Tvedit's A command). |
| [K] | Kills the character under the cursor, or n chars starting at the cursor. |
| [cr] | When the buffer is empty is the same as <lf>, i.e. restores buffer's previous contents. Otherwise is just like a <cr> (except that it also terminates an insert). Thus, [<cr><cr>] will repeat the previous input (as will <lf><cr> without the meta key). |
| [O] | Does "Open line", inserting a crlf after the cursor, i.e., it breaks the line but leaves the cursor where it is. |

[T] Transposes the characters before and after the cursor. When typed at the end of a line, transposes the previous two characters. Refuses to handle funny cases, such as tabs.

[G] Grabs the contents of the previous line from the cursor position onward. [nG] grabs the nth previous line.

[L] Lowercases current word, or n words on line. [$L] lowercases the rest of the line, or if given at the end of line lowercases the entire line.

[U] Uppercases analogously.

[C] Capitalize. If you give it an argument, only the first word is capitalized; the rest are just lowercased.

[control-Q] Deletes the current line. [$control-Q] deletes from the current cursor position to the end of the buffer. No other arguments are handled.

[control-W] Deletes the current word, or the previous word if sitting on a space.

[J] "Justify" this line. This will break it if it is too long, or move words up from the next line if too short. Will not join to an empty line, or one starting with a tab (both of which are interpreted as paragraph breaks). Any new line breaks it introduces are considered spaces, not carriage returns. [nJ] justifies n lines.

The linelength is defined as **TTYJUSTLENGTH**, ignoring any prompt characters at the margin. If **TTYJUSTLENGTH** is negative, it is interpreted as relative to the right margin. **TTYJUSTLENGTH** is initially -8 in Interlisp-D, 72 in Interlisp-10.

[$F] "Finishes" the input, regardless of where the cursor is. Specifically, it goes to the end of the input and enters a <cr>, control-Z or "]", depending on whether normal, **REPEAT** or **READ** input is happening. Note that a "]" won't necessarily end a **READ**, but it seems likely to in most cases where you would be inclined to use this command, and makes for more predictable behavior.

Miscellaneous Commands:

[P] Interlisp-D: Prettyprint buffer. Clears the buffer and reprints it using prettyprint. If there are not enough right parentheses, it will supply more; if there are too many, any excess remains unprettyprinted at the end of the buffer. May refuse to do anything if there is an unclosed string or other error trying to read the buffer.

[N] Refresh line. Same as control-R. [$N] refreshes the whole buffer; [nN] refreshes n lines. Cursor movement in TTYIN depends on TTYIN being the only source of output to the screen; if you do a control-T, or a system message appears, or line noise occurs, you may need to refresh the line for best results. In Interlisp-10, if for some reason your terminal falls out of binary mode (e.g. can happen when returning to a Lisp running in a lower fork), Meta-<anything> is unreadable, so you'd have to type control-R instead.

[control-Y] Gets user exec. Thus, this is like regular control-Y, except when doing a READ (when control-Y is a read macro and hence does not invoke this function).

[$control-Y] Gets a user exec, but first unreads the contents of the buffer from the cursor onward. Thus if you typed at TTYIN something destined for the Lisp executive, you can do [control-L$control-Y] and give it to Lisp.

[←] Adds the current word to the spelling list **USERWORDS**. With zero arg, removes word. See **TTYINCOMPLETEFLG** (page 26.37).

Note to Datamedia, Heath users: In addition to simple cursor movement commands and insert/delete, TTYIN uses the display's cursor-addressing capability to optimize cursor movements longer than a few characters, e.g. [tab] to go to the end of the line. In order to be able to address the cursor, TTYIN has to know where it is to begin with. Lisp keeps track of the current print position within the line, but does not keep track of the line on the screen (in fact, it knows precious little about displays, much like Tenex). Thus, TTYIN establishes where it is by forcing the cursor to appear on the last line of the screen. Ordinarily this is the case anyway (except possibly on startup), but if the cursor happens to be only halfway down the screen at the time, there is a possibly unsettling leap of the cursor when TTYIN starts.

## 26.4.4 Using TTYIN for Lisp Input

When TTYIN is loaded, or a sysout containing TTYIN is started up, the function **SETREADFN** is called. If the terminal is a display, it sets **LISPXREADFN** (page 13.36) to be **TTYINREAD**. If the terminal is not a display terminal, **SETREADFN** will set the variable to **READ**. **(SETREADFN 'READ)** will also set it to **READ**.

There are two principal differences between **TTYINREAD** and **READ**: (1) parenthesis balancing. The input does not activate on an exactly balancing right paren/bracket unless the input started with a paren/bracket, e.g., "**USE (FOO) FOR (FIE)**" will all be on one line, terminated by <cr>; and (2) read macros.

In Interlisp-10, TTYIN does not use a read table (TTYIN behaves as though using the default initial Lisp terminal input readtable), so read macros and redefinition of syntax characters are not supported; however, " ' " **(QUOTE)** and "control-Y" **(EVAL)** are built in, and a simple implementation of ? and ?= is supplied. Also, the **TTYINREADMACROS** facility described below can supply some of the functionality of immediate read macros in the editor.

In Interlisp-D, read macros are (mostly) supported. Immediate read macros take effect only if typed at the end of the input (it's not clear what their semantics should be elsewhere).

## 26.4.5 Useful Macros

There are two useful edit macros that allow you to use TTYIN as a character editor: (1) **ED** loads the current expression into the ttyin buffer to be edited (this is good for editing comments and strings). Input is terminated in the usual way (by typing a balancing right parenthesis at the end of the input, typing <cr> at the end of an already balanced expression, or control-X anywhere inside the balanced expression). Typing control-E or clearing the buffer aborts **ED**. (2) **EE** is like **ED** but prettyprints the expression into the buffer, and uses its own window. The variable **TTYINEDITPROMPT** controls what prompt, if any, **EE** uses. If it is **T** (initial value), no prompt is printed. **EE** is not implemented in Interlisp-10.

The macro **BUF** loads the current expression into the buffer, preceded by **E**, to be used as input however desired; as a trivial example, to evaluate the current expression, **BUF** followed by a <cr> to activate the buffer will perform roughly what the edit macro **EVAL** does. Of course, you can edit the **E** to something else to make it an edit command.

**BUF** is also defined at the executive level as a programmer's assistant command that loads the buffer with the **VALUEOF** the indicated event, to be edited as desired.

**TV** is a programmer's assistant command like EV [EDITV] that performs an **ED** on the value of the variable.

And finally, if the event is considered "short" enough, the programmer's assistant command **FIX** will load the buffer with the event's input, rather than calling the editor. If you really wanted the Interlisp editor for your fix, you could either say **FIX** *EVENT* - **TTY:**, or type control-U (or whatever on tops20) once you got TTYIN's version to force you into the editor.

## 26.4.6 Programming With TTYIN

(**TTYIN** *PROMPT SPLST HELP OPTIONS ECHOTOFILE TABS UNREADBUF RDTBL*) [Function]

TTYIN prints *PROMPT*, then waits for input. The value returned in the normal case is a list of all atoms on the line, with comma and parens returned as individual atoms; *OPTIONS* may be used to get a different kind of value back.

*PROMPT* is an atom or string (anything else is converted to a string). If **NIL**, the value of **DEFAULTPROMPT**, initially "** ", will be used. If *PROMPT* is **T**, no prompt will be given. *PROMPT* may also be a dotted pair ($PROMPT_1$ . $PROMPT_2$), giving the prompt for the first and subsequent (or overflow) lines, each prompt being a string/atom or **NIL** to denote absence of prompt. The default prompt for overflow lines is "... ". Note that rebinding **DEFAULTPROMPT** gives a convenient way to affect all the "ordinary" prompts in some program module.

*SPLST* is a spelling list, i.e., a list of atoms or dotted pairs (*SYNONYM* . *ROOT*). If supplied, it is used to check and correct user responses, and to provide completion if the user types escape. If *SPLST* is one of the Lisp system spelling lists (e.g., **USERWORDS** or **SPELLINGS3**), words that are escape-completed get moved to the front, just as if a **FIXSPELL** had found them. Autocompletion is also performed when user types a break character (cr, space, paren, etc), unless one of the "nofixspell" options below is selected; i.e., if the word just typed would uniquely complete by escape, TTYIN behaves as though escape had been typed.

*HELP*, if non-**NIL**, determines what happens when the user types ? or HELP. If *HELP* = **T**, program prints back *SPLST* in suitable form. If *HELP* is any other litatom, or a string containing no spaces, it performs (**DISPLAYHELP** *HELP*). Anything else is printed as is. If *HELP* is **NIL**, ? and HELP are treated as any other atoms the user types. [**DISPLAYHELP** is a user-supplied function, initially a noop; systems with a suitable HASH package, for example, have defined it to display a piece of text from a hashfile associated with the key **HELP**.]

*OPTIONS* is an atom or list of atoms chosen from among the following:

**NOFIXSPELL** Uses *SPLST* for HELP and Escape completion, but does not attempt any **FIXSPELL**ing. Mainly useful if *SPLST* is incomplete and the caller wants to handle corrections in a more flexible way than a straight **FIXSPELL**.

**MUSTAPPROVE** Does spelling correction, but requires confirmation.

**CRCOMPLETE** Requires confirmation on spelling correction, but also does autocompletion on <cr> (i.e. if what user has typed so far uniquely identifies a member of *SPLST*, completes it). This allows you to have the benefits of autocompletion and still allow new words to be typed.

**DIRECTORY** (only if *SPLST* = **NIL**) Interprets Escape to mean directory name completion [Interlisp-10 only].

**USER** Like **DIRECTORY**, but does username completion. This is identical to **DIRECTORY** under Tenex [Interlisp-10 only].

**FILE** (only if *SPLST* = **NIL**) Interprets Escape to mean filename completion [Sumex and Tops20 only].

**FIX** If response is not on, or does not correct to, *SPLST*, interacts with user until an acceptable response is entered. A blank line (returning **NIL**) is always accepted. Note that if you are willing to accept responses that are not on *SPLST*, you probably should specify one of the options **NOXFISPELL**, **MUSTAPPROVE** or **CRCOMPLETE**, lest the user's new response get **FIXSPELL**ed away without their approval.

**STRING** Line is read as a string, rather than list of atoms. Good for free text.

**NORAISE** Does not convert lower case letters to upper case.

**NOVALUE** For use principally with the *ECHOTOFILE* arg (below). Does not compute a value, but returns **T** if user typed anything, **NIL** if just a blank line.

**REPEAT** For multi-line input. Repeatedly prompts until user types control-Z (as in Tenex sndmsg). Returns one long list; with **STRING** option returns a single string of everything typed, with carriage returns (EOL) included in the string.

**TEXT** Implies **REPEAT**, **NORAISE**, and **NOVALUE**. Additionally, input may be terminated with control-V, in which case the global flag **CTRLVFLG** will be set true (it is set to **NIL** on any other termination). This flag may be utilized in any way the caller desires.

**COMMAND** Only the first word on the line is treated as belonging to *SPLST*, the remainder of the line being arbitrary text; i.e., "command format". If other options are supplied, **COMMAND** still applies to the first word typed. Basically, it always returns **(***CMD* **.** *REST-OF-INPUT***)**, where *REST-OF-INPUT* is whatever the other options dictate for the remainder. E.g. **COMMAND NOVALUE** returns **(***CMD***)** or **(***CMD* **. T)**, depending on whether there was further input; **COMMAND STRING** returns **(***CMD* **.** **"***REST-OF-INPUT***")**. When used with **REPEAT**, **COMMAND** is only in effect for the first line typed; furthermore, if the first line consists solely of a command, the **REPEAT** is ignored, i.e., the entire input is taken to be just the command.

**READ** Parens, brackets, and quotes are treated a la **READ**, rather than being returned as individual atoms. Control characters may be input via the control-Vx notation. Input is terminated roughly along the lines of **READ** conventions: a balancing or over-balancing right paren/bracket will activate the input, or <cr> when no parenthesis remains unbalanced. **READ** overrides all other options (except **NORAISE**).

**LISPXREAD** Like **READ**, but implies that TTYIN should behave even more like **READ**, i.e., do **NORAISE**, not be errorset-protected, etc.

**NOPROMPT** Interlisp-D only: The prompt argument is treated as usual, except that TTYIN assumes that the prompt for the first line has already been printed by the caller; the prompt for the first line is thus used only when redisplaying the line.

*ECHOTOFILE* if specified, user's input is copied to this file, i.e., TTYIN can be used as a simple text-to-file routine if **NOVALUE** is used. If *ECHOTOFILE* is a list, copies to all files in the list. *PROMPT* is not included on the file.

*TABS* is a special addition for tabular input. It is a list of tabstops (numbers). When user types a tab, TTYIN automatically spaces over to the next tabstop (thus the first tabstop is actually the second "column" of input). Also treats specially the characters * and "; they echo normally, and then automatically tab over.

*UNREADBUF* allows the caller to "preload" the TTYIN buffer with a line of input. *UNREADBUF* is a list, the elements of which are unread into the buffer (i.e., "the outer parentheses are stripped off") to be edited further as desired; a simple carriage return (or control-Z for **REPEAT** input) will thus cause the buffer's contents to be returned unchanged. If doing **READ** input, the "**PRIN2** names" of the input list are used, i.e., quotes and %'s will appear as needed; otherwise the buffer will look as though *UNREADBUF* had been **PRIN1**'ed. *UNREADBUF* is treated somewhat like **READBUF**, so that if it contains a pseudo-carriage return (the value of **HISTSTR0**), the input line terminates there.

Input can also be unread from a file, using the **HISTSTR1** format: *UNREADBUF* = (<*value of* **HISTSTR1**> (*FILE START* . *END*)), where *START* and *END* are file byte pointers. This makes TTYIN a miniature text file editor.

*RDTBL* [Interlisp-D only] is the read table to use for **READ**ing the input when one of the **READ** options is given. A lot of character interpretations are hardwired into TTYIN, so currently the only effect this has is in the actual **READ**, and in deciding whether a character typed at the end of the input is an immediate read macro, for purposes of termination.

If the global variable **TYPEAHEADFLG** is **T**, or option **LISPXREAD** is given, TTYIN permits type-ahead; otherwise it clears the buffer before prompting the user.

### 26.4.7 Using TTYIN as a General Editor

The following may be useful as a way of outsiders to call TTYIN as an editor. These functions are currently only in Interlisp-D.

**(TTYINEDIT** *EXPRS WINDOW PRINTFN PROMPT***)** [Function]

This is the body of the edit macro **EE**. Switches the tty to *WINDOW*, clears it, prettyprints *EXPRS*, a list of expressions, into it, and leaves you in TTYIN to edit it as Lisp input. Returns a new list of expressions.

If *PRINTFN* is non-**NIL**, it is a function of two arguments, *EXPRS* and *FILE*, which is called instead of **PRETTYPRINT** to print the expressions to the window (actually to a scratch file). Note that *EXPRS* is a list, so normally the outer parentheses should not be printed. *PRINTFN* = T is shorthand for "unpretty"; use **PRIN2** instead of **PRETTYPRINT**.

*PROMPT* determines what prompt is printed, if any. If **T**, no prompt is printed. If **NIL**, it defaults to the value of **TTYINEDITPROMPT**.

**TTYINAUTOCLOSEFLG** [Variable]

If **TTYINAUTOCLOSEFLG** is true, **TTYINEDIT** closes the window on exit.

**TTYINEDITWINDOW** [Variable]

If the *WINDOW* arg to **TTYINEDIT** is **NIL**, it uses the value of **TTYINEDITWINDOW**, creating it if it does not yet exist.

**TTYINPRINTFN** [Variable]

The default value for *PRINTFN* in **EE**'s call to **TTYINEDIT**.

**(SET.TTYINEDIT.WINDOW** *WINDOW***)** [Function]

Called under a **RESETLST**. Switches the tty to *WINDOW* (defaulted as in **TTYINEDIT**) and clears it. The window's position is left so that TTYIN will be happy with it if you now call TTYIN yourself. Specifically, this means positioning an integral number of lines from the bottom of the window, the way the top-level tty window normally is.

**(TTYIN.SCRATCHFILE)** [Function]

Returns, possibly creating, the scratchfile that TTYIN uses for prettyprinting its input. The file pointer is set to zero. Since TTYIN does use this file, beware of multiple simultaneous use of the file.

## 26.4.8 ?= Handler

In Interlisp, the ?= read macro displays the arguments to the function currently "in progress" in the typein. Since TTYIN wants you to be able to continue editing the buffer after a ?=, it processes this macro specially on its own, printing the arguments below your typein and then putting the cursor back where it was when ?= was typed. For users who want special treatment of ?=, the following hook exists:

**TTYIN?=FN** [Variable]

The value of this variable, if non-**NIL**, is a user function of one argument that is called when ?= is typed. The argument is the function that ?= thinks it is inside of. The user function should return one of the following:

**NIL** Normal ?= processing is performed.

**T** Nothing is done. Presumably the user function has done something privately, perhaps diddled some other window, or called **TTYIN.PRINTARGS** (below).

a list **(ARGS .** ***STUFF*****)** Treats *STUFF* as the argument list of the function in question, and performs the normal ?= processing using it.

anything else The value is printed in lieu of what ?= normally prints.

At the time that ?= is typed, nothing has been "read" yet, so you don't have the normal context you might expect inside a conventional readmacro. If the user function wants to examine the typed-in arguments being passed to the fn, however, it can call the function **TTYIN.READ?=ARGS**:

**(TTYIN.READ?=ARGS)** [Function]

When called inside **TTYIN?=FN** user function, returns everything between the function and the typing of ?= as a list (like an arglist). Returns **NIL** if ?= was typed immediately after the function name.

**(TTYIN.PRINTARGS** *FN ARGS ACTUALS ARGTYPE***)** [Function]

Does the function/argument printing for ?=. *ARGS* is an argument list, *ACTUALS* is a list of actual parameters (from the typein) to match up with args. *ARGTYPE* is a value of the function **ARGTYPE**; it defaults to **(ARGTYPE** *FN***)**.

## 26.4.9 Read Macros

When doing **READ** input in Interlisp-10, no Lisp-style read macros are available (but the ' and control-Y macros are built in). Principally because of the usefulness of the editor read macros (set by **SETTERMCHARS**), and the desire for a way of changing the meanings of the display editing commands, the following exists as a hack:

**TTYINREADMACROS** [Variable]

Value is a set of shorthand inputs useable during **READ** input. It is an alist of entries (*CHARCODE* . *SYNONYM*). If the user types the indicated character (the meta bit is denoted by the 200Q bit in the char code), TTYIN behaves as though the synonym character had been typed.

Special cases: 0 - the character is ignored; 200Q - pure meta bit; means to read another char and turn on its meta bit; 400Q - macro quote: read another char and use its original meaning. For example, if you have macros ((33Q . 200Q) (30Q . 33Q)), then Escape (33Q) will behave as an edit prefix, and control-X (30Q) will behave like Escape. Note: currently, synonyms for meta commands are not well-supported, working only when the command is typed with no argument.

Slightly more powerful macros also can be supplied; they are recognized when a character is typed on an empty line, i.e., as the first thing after the prompt. In this case, the **TTYINREADMACROS** entry is of the form (*CHARCODE* **T** . *RESPONSE*) or (*CHARCODE* *CONDITION* . *RESPONSE*), where *CONDITION* is a list that evaluates true. If *RESPONSE* is a list, it is **EVAL**ed; otherwise it is left unevaluated. The result of this evaluation (or *RESPONSE* itself) is treated as follows:

**NIL** The macro is ignored and the character reads normally, i.e., as though **TTYINREADMACROS** had never existed.

An integer A character code, treated as above. Special case: -1 is treated like 0, but says that the display may have been altered in the evaluation of the macro, so TTYIN should reset itself appropriately.

Anything else This TTYIN input is terminated (with a crlf) and returns the value of "response" (turned into a list if necessary). This is the principal use of this facility. The macro character thus stands for the (possibly computed) reponse, terminated if necessary with a crlf. The original character is not echoed.

Interrupt characters, of course, cannot be read macros, as TTYIN never sees them, but any other characters, even non-control chars, are allowed. The ability to return **NIL** allows you to have conditional macros that only apply in specified situations (e.g., the macro might check the prompt **(LISPXID)** or other contextual variables). To use this specifically to do immediate editor read macros, do the following for each edit command and character you want to invoke it with:

**(ADDTOVAR TTYINREADMACROS (***CHARCODE* **'CHARMACRO?** *EDITCOM***)))**

For example, **(ADDTOVAR TTYINREADMACROS (12Q CHARMACRO? !NX))** will make linefeed do the **!NX** command.

Note that this will only activate linefeed at the beginning of a line, not anywhere in the line. There will probably be a user function to do this in the next release.

Note that putting **(12Q T . !NX)** on **TTYINREADMACROS** would also have the effect of returning **"!NX"** from the **READ** call so that the editor would do an **!NX**. However, TTYIN would also return **!NX** outside the editor (probably resulting in a u.b.a. error, or convincing DWIM to enter the editor), and also the clearing of the output buffer (performed by **CHARMACRO**?) would not happen.

## 26.4.10 Assorted Flags

These flags control aspects of TTYIN's behavior. Some have already been mentioned. In Interlisp-D, the flags are all initially set to **T**.

**TYPEAHEADFLG** [Variable]

If true, TTYIN always permits typeahead; otherwise it clears the buffer for any but **LISPXREAD** input.

**?ACTIVATEFLG** [Variable]

If true, enables the feature whereby ? lists alternative completions from the current spelling list.

**SHOWPARENFLG** [Variable]

If true, then whenever you are typing Lisp input and type a right parenthesis/bracket, TTYIN will briefly move the cursor to the matching parenthesis/bracket, assuming it is still on the screen. The cursor stays there for about 1 second, or until you type another character (i.e., if you type fast you'll never notice it). This feature was inspired by a similar EMACS feature, and turned out to be pretty easy to implement.

**TTYINBSFLG** [Variable]

Causes TTYIN to always physically backspace, even if you're running on a non-display (not a DM or Heath), rather than print \deletedtext\ (this assumes your hardcopy terminal or glass tty is capable of backspacing). If TTYINBSFLG is LF, then in addition to backspacing, TTYIN x's out the deleted characters as it backs up, and when you stop deleting, it outputs a linefeed to drop to a new, clean line before resuming. To save paper, this linefeed operation is not done when only a single character is deleted, on the grounds that you can probably figure out what you typed anyway.

**TTYINRESPONSES** [Variable]

An association list of special responses that will be handled by routines designated by the programmer. See "Special Responses", below.

**TTYINERRORSETFLG** [Variable]

[Interlisp-D only] If true, non-**LISPXREAD** inputs are errorset-protected (control-E traps back to the prompt), otherwise errors propagate upwards. Initially **NIL**.

**TTYINCOMMENTCHAR** [Variable]

This variable affects the treatment of lines beginning with the comment character (usually ";"). If **TTYINCOMMENTCHAR** is a character code, and the first character on a line of typein is equal to **TTYINCOMMENTCHAR**, then the line is erased from the screen and no input function will see it. If **TTYINCOMMENTCHAR** is **NIL**, this feature is disabled. **TTYINCOMMENTCHAR** is initially **NIL**.

**TTYINCOMPLETEFLG** [Variable]

If true, enables Escape completion from **USERWORDS** during READ inputs. Details below.

**USERWORDS** (page 20.17) contains words you mentioned recently: functions you have defined or edited, variables you have set or evaluated at the executive level, etc. This happens to be a very convenient list for context-free escape completion; if you have recently edited a function, chances are good you may want to edit it again (typing "EF xx$") or type a call to it. If there is no completion for the current word from **USERWORDS**, the escape echoes as "$", i.e. nothing special happens; if there is more than one possible completion, you get beeped. If typed when not inside a word, Escape completes to the value of **LASTWORD**, i.e., the last thing you typed that the p.a. "noticed" (setting **TTYINCOMPLETEFLG** to 0 disables this latter feature), except that Escape at the beginning of the line is left alone (it is a p.a. command).

If you really wanted to enter an escape, you can, of course, just quote it with a control-V, like you can other control chars.

You may explicitly add words to **USERWORDS** yourself that wouldn't get there otherwise. To make this convenient online the edit command [←] means "add the current atom to **USERWORDS**" (you might think of the command as "pointing out this atom"). For example, you might be entering a function definition and want to "point to" one or more of its arguments or prog variables. Giving an argument of zero to this command will instead remove the indicated atom from **USERWORDS**.

Note that this feature loses some of its value if the spelling list is too long, for then the completion takes too long computationally and, more important, there are too many alternative completions for you to get by with typing a few characters followed by escape. Lisp's maintenance of the spelling list **USERWORDS** keeps the "temporary" section (which is where everything goes initially unless you say otherwise) limited to **#USERWORDS** atoms, initially 100. Words fall off the end if they haven't been used (they are "used" if **FIXSPELL** corrects to one, or you use <escape> to complete one).

## 26.4.11 Special Responses

There is a facility for handling "special responses" during any non-**READ** TTYIN input. This action is independent of the particular call to TTYIN, and exists to allow you to effectively "advise" TTYIN to intercept certain commands. After the command is processed, control returns to the original TTYIN call. The facility is implemented via the list **TTYINRESPONSES**.

**TTYINRESPONSES** [Variable]

**TTYINRESPONSES** is a list of elements, each of the form:

(*COMMANDS RESPONSE-FORM OPTION*)

*COMMANDS* is a single atom or list of commands to be recognized; *RESPONSE-FORM* is **EVAL**ed (if a list), or **APPLY**ed (if an atom) to the command and the rest of the line. Within this form one can reference the free variables **COMMAND** (the command the user typed) and **LINE** (the rest of the line). If *OPTION* is the atom **LINE**, this means to pass the rest of line as a list; if it is **STRING**, this means to pass it as a string; otherwise, the command is only valid if there is nothing else on the line. If *RESPONSE-FORM* returns the atom **IGNORE**, it is not treated as a special response (i.e. the input is returned normally as the result of TTYIN).

Suggested use: global commands or options can be added to the toplevel value of **TTYINRESPONSES**. For more specialized commands, rebind **TTYINRESPONSES** to **(APPEND** *NEWENTRIES* **TTYINRESPONSES)** inside any module where you want to do this sort of special processing.

Special responses are not checked for during **READ**-style input.

## 26.4.12 Display Types

[This is not relevant in Interlisp-D]

TTYIN determines the type of display by calling **DISPLAYTERMP**, which is initially defined to test the value of the **GTTYP** jsys. It returns either **NIL** (for printing terminals) or a small number giving TTYIN's internal code for the terminal type. The types TTYIN currently knows about:

0 = glass tty (capable of deleting chars by backspacing, but little else);

1 = Datamedia;

2 = Heath.

Only the Datamedia has full editing power. **DISPLAYTERMP** has built into it the correct terminal types for Sumex and Stanford campus 20's: Datamedia = 11 on tenex, 5 on tops20; Heath = 18 on Tenex, 25 on tops20. You can override those values by setting the variable **DISPLAYTYPES** to be an association list associating the **GTTYP** value with one of these internal codes. For example, Sumex displays correspond to **DISPLAYTYPES = ((11 . 1) (18 . 2))** [although this is actually compiled into **DISPLAYTERMP** for speed]. Any display terminal other than Datamedia and Heath can probably safely be assigned to "0" for glass tty.

To add new terminal types, you have to choose a number for it, add new code to TTYIN for it and recompile. The TTYIN code specifies what the capabilities of the terminal are, and how to do the primitive operations: up, down, left, right, address cursor, erase screen, erase to end of line, insert character, etc.

For terminals lacking a meta key (currently only Datamedias have it), set the variable **EDITPREFIXCHAR** to the ascii code of an edit "prefix" (i.e. anything typed preceded by the prefix is considered to have the meta bit on). If your **EDITPREFIXCHAR** is 33Q (Escape), you can type a real Escape by typing 3 of them (2 won't do, since that means "Meta-Escape", a legitimate argument to another command). You could also define an Escape synonym with **TTYINREADMACROS** if you wanted (but currently it doesn't work in filename completion). Setting **EDITPREFIXCHAR** for a terminal that is not equipped to handle the full range of editing functions (only the Heath and Datamedia are currently so equipped) is not guaranteed to work, i.e. the display will not always be up to date; but if you can keep track of what you're doing, together with an occasional control-R to help out, go right ahead.

## 26.5 Prettyprint

The standard way of printing out function definitions (on the terminal or into files) is to use **PRETTYPRINT**.

**(PRETTYPRINT** *FNS PRETTYDEFLG* **—)** [Function]

*FNS* is a list of functions. If *FNS* is atomic, its value is used). The definitions of the functions are printed in a pretty format on the primary output file using the primary readtable. For example, if **FACTORIAL** were defined by typing

```
(DEFINEQ (FACTORIAL [LAMBDA (N) (COND ((ZEROP N) 1)
(T (ITIMES N (FACTORIAL (SUB1 N]
```

**(PRETTYPRINT '(FACTORIAL))** would print out

```
(FACTORIAL
 [LAMBDA (N)
  (COND
   ((ZEROP N)
    1)
   (T (ITIMES N (FACTORIAL (SUB1 N])
```

*PRETTYDEFLG* is **T** when called from **PRETTYDEF** (and hence **MAKEFILE**). Among other actions taken when this argument is true, **PRETTYPRINT** indicates its progress in writing the current output file: whenever it starts a new function, it prints on the terminal the name of that function if more than 30 seconds (real time) have elapsed since the last time it printed the name of a function.

**PRETTYPRINT** operates correctly on functions that are **BROKEN**, **BROKEN-IN**, **ADVISED**, or have been compiled with their definitions saved on their property lists: it prints the original, pristine definition, but does not change the current state of the function. If a function is not defined but is known to be on one of the files noticed by the file package, **PRETTYPRINT** loads in the definition (using **LOADFNS**) and prints it (except when called from **PRETTYDEF**). If **PRETTYPRINT** is given an atom which is not the name of a function, but has a value, it prettyprints the value. Otherwise, **PRETTYPRINT** attempts spelling correction. If all fails, **PRETTYPRINT** returns **(***FN* **NOT PRINTABLE)**. Note that **PRETTYPRINT** will return **(***FN* **NOT PRINTABLE)** if *FN* does not have an accessable expr definition, or if it doesn't have any definition at all.

**(PP** $FN_1$ ... $FN_N$**)** [NLambda NoSpread Function]

For prettyprinting functions to the terminal. **PP** calls **PRETTYPRINT** with the primary output file set to **T** and the primary read table set to **T**. The primary output file and primary readtable are restored after printing.

**(PP FOO)** is equivalent to **(PRETTYPRINT '(FOO))**; **(PP FOO FIE)** is equivalent to **(PRETTYPRINT '(FOO FIE))**.

As described above, when **PRETTYPRINT**, and hence **PP**, is called with the name of a function that is not defined, but whose definition is on a file known to the file package, the definition is automatically read in and then prettyprinted. However, if the user does not intend on editing or running the definition, but simply wants to see the definition, the function **PF** described below can be used to simply copy the corresponding characters from the file to the terminal. This results in a savings in both space and time, since it is not necessary to allocate storage to actually read in the definition, and it is not necessary to re-prettyprint it (since the function is already in prettyprint format on the file).

**(PF** ***FN FROMFILES TOFILE*****)** [NLambda NoSpread Function]

Copies the definition of *FN* found on each of the files in *FROMFILES* to *TOFILE*. If *TOFILE* = **NIL**, defaults to **T**. If *FROMFILES* = **NIL**, defaults to **(WHEREIS** *FN* **NIL T)** (see page 17.14). The typical usage of **PF** is simply to type "**PF** *FN*".

**PF** prints a message if it can't find a file on *FROMFILES*, or it can't find the function *FN* on a file.

When printing to the terminal, **PF** performs several transformations on the characters in the file that comprise the definition for *FN*: (1) font information is stripped out (except in Interlisp-D, whose display supports multiple fonts); (2) occurrences of the **CHANGECHAR** (page 26.49) are not printed; (3) since functions typically tend to be printed to a file with a larger linelength than when printing to a terminal, the number of leading spaces on each line is cut in half (unless **PFDEFAULT** is **T**; initially **NIL**); and (4) comments are elided, if ****COMMENT**FLG** is non-**NIL** (see page 26.43).

**(SEE** ***FROMFILE TOFILE*****)** [NLambda NoSpread Function]

Copies all of the text from *FROMFILE* to *TOFILE* (defaults to **T**), processing all text as **PF** does. Used to display the contents of files on the terminal.

**(PP*** ***X*****)** [NLambda NoSpread Function]

**(PF*** ***FN FROMFILES TOFILE*****)** [NLambda NoSpread Function]

**(SEE*** ***FROMFILE TOFILE*****)** [NLambda NoSpread Function]

These functions operate exactly like **PP**, **PF**, and **SEE**, except that they bind ****COMMENT**FLG** to **NIL**, so comments are printed in full (see page 26.43).

While the function **PRETTYPRINT** prints entire function definitions, the function **PRINTDEF** can be used to print parts of functions, or arbitrary Interlisp structures:

**(PRINTDEF** *EXPR LEFT DEF TAILFLG FNSLST FILE***)** [Function]

Prints the expression *EXPR* in a pretty format on *FILE* using the primary readtable. *LEFT* is the left hand margin (**LINELENGTH** determines the right hand margin). **PRINTDEF** initially performs **(TAB** *LEFT* **T)**, which means to space to position *LEFT*, unless already beyond this position, in which case it does nothing.

*DEF* = **T** means *EXPR* is a function definition, or a piece of one. If *DEF* = **NIL**, no special action is taken for **LAMBDA**'s, **PROG**'s, **COND**'s, comments, CLISP, etc. *DEF* is **NIL** when **PRETTYDEF** calls **PRETTYPRINT** to print variables and property lists, and when **PRINTDEF** is called from the editor via the command **PPV**.

*TAILFLG* = **T** means *EXPR* is interpreted as a tail of a list, to be printed without parentheses.

*FNSLST* is for use for printing with multiple fonts (page 27.25). **PRINTDEF** prints occurrences of any function in the list *FNSLST* in a different font, for emphasis. **MAKEFILE** passes as *FNSLST* the list of all functions on the file being made.

## 26.5.1 Comment Feature

A facility for annotating Interlisp functions is provided in **PRETTYPRINT**. Any expression beginning with the atom * is interpreted as a comment and printed in the right margin. Example:

```
(FACTORIAL
 [LAMBDA (N)               (* COMPUTES N!)
   (COND
    ((ZEROP N)            (* 0! = 1)
     1)
    (T                 (* RECURSIVE DEFINITION:
                        N! = N*N-1!)
     (ITIMES N (FACTORIAL (SUB1 N])
```

These comments actually form a part of the function definition. Accordingly, * is defined as an nlambda nospread function that returns its argument, similar to **QUOTE**. When running an interpreted function, * is entered the same as any other Interlisp function. Therefore, comments should only be placed where they will not harm the computation, i.e., where a quoted expression could be placed. For example, writing

**(ITIMES N (FACTORIAL (SUB1 N)) (* RECURSIVE DEFINITION))**

in the above function would cause an error when **ITIMES** attempted to multiply **N, N-1!**, and **RECURSIVE**.

For compilation purposes, * is defined as a macro which compiles into no instructions (unless the comment has been placed where it has been used for value, in which case the compiler prints an appropriate error message and compiles * as **QUOTE**). Thus, the compiled form of a function with comments does not use the extra atom and list structure storage required by the comments in the source (interpreted) code. This is the way the comment feature is intended to be used.

A comment of the form **(* E** *X***)** causes *X* to be evaluated at prettyprint time, as well as printed as a comment in the usual way. For example, **(* E (RADIX 8))** as a comment in a function containing octal numbers can be used to change the radix to produce more readable printout.

The comment character * is stored in the variable **COMMENTFLG**. The user can set it to some other value, e.g. ";", and use this to indicate comments.

**COMMENTFLG** [Variable]

If **CAR** of an expression is **EQ** to **COMMENTFLG**, the expression is treated as a comment by **PRETTYPRINT**. **COMMENTFLG** is initialized to *. Note that whatever atom is chosen for **COMMENTFLG** should also have an appropriate function definition and compiler macro, for example, by copying those of *.

Comments are designed mainly for documenting *listings*. Therefore, when prettyprinting to the terminal, comments are suppressed and printed as the string ****COMMENT****. The value of ****COMMENT**FLG** determines the action.

****COMMENT**FLG** [Variable]

If ****COMMENT**FLG** is **NIL**, comments are printed. Otherwise, the value of ****COMMENT**FLG** is printed. Initially " ****COMMENT**** ".

**(COMMENT1** *L* **—)** [Function]

Prints the comment *L*. **COMMENT1** is a separate function to permit the user to write prettyprint macros (page 26.48) that use the regular comment printer. For example, to cause comments to be printed at a larger than normal linelength, one could put an entry for * on **PRETTYPRINTMACROS**:

**(* LAMBDA (X) (RESETFORM (LINELENGTH 100) (COMMENT1 X)))**

This macro resets the line length, prints the comment, and then restores the line length.

**COMMENT1** expects to be called from within the environment established by **PRINTDEF**, so ordinarily the user should call it *only* from within prettyprint macros.

## 26.5.2 Comment Pointers

For a well-commented collection of programs, the list structure, atom, and print name storage required to represent the comments in core can be significant. If the comments already appear on a file and are not needed for editing, a significant savings in storage can be achieved by simply leaving the text of the comment on the file when the file is loaded, and instead retaining in core only a *pointer* to the comment. When this feature is enabled, * is defined as a read macro (page 25.39) in **FILERDTBL** which, instead of reading in the entire text of the comment, constructs an expression containing (1) the name of the file in which the text of the comment is contained, (2) the address of the first character of the comment, (3) the number of characters in the comment, and (4) a flag indicating whether the comment appeared at the right hand margin or centered on the page. For output purposes, * is defined on **PRETTYPRINTMACROS** (page 26.48) so that it prints the comments represented by such pointers by simply copying the corresponding characters from one file to another, or to the terminal. Normal comments are processed the same as before, and can be intermixed freely with comment pointers.

The comment pointer feature is controlled by the function **NORMALCOMMENTS**.

**(NORMALCOMMENTS** ***FLG*****)** [Function]

If *FLG* is **NIL**, the comment pointer feature is enabled. If *FLG* is **T**, the comment pointer feature is disabled (the default).

**NORMALCOMMENTS** can be changed as often as desired. Thus, some files can be loaded normally, and others with their comments converted to comment pointers.

For convenience of editing selected comments, an edit macro, **GET***, is included, which loads in the text of the corresponding comment. The editor's **PP*** command, in contrast, prints the comment *without* reading it by simply copying the corresponding characters to the terminal. **GET*** is defined in terms of **GETCOMMENT**:

**(GETCOMMENT** ***X DESTFL —*****)** [Function]

If *X* is a comment pointer, replaces *X* with the actual text of the comment, which it reads from its file. Returns *X* in all cases. If

*DESTFL* is non-**NIL**, it is the name of an open file, to which **GETCOMMENT** copies the comment; in this case, *X* remains a comment pointer, but it has been changed to point to the new file (unless **NORMALCOMMENTS** has been set to **DONTUPDATE**).

**(PRINTCOMMENT** *X***)** [Function]

Defined as the prettyprint macro for *: copies the comment to the primary output file by using **GETCOMMENT**.

**(READCOMMENT** *FL RDTBL LST***)** [Function]

Defined as the read macro for * in **FILERDTBL**: if **NORMALCOMMENTSFLG** is **NIL**, it constructs a comment pointer, unless it believes the expression beginning with * is not actually a comment, e.g., if the next atom is "." or **E**.

Note that a certain amount of care is required in using the comment pointer feature. Since the text of the comment resides on the file pointed to by the comment pointer, that file must remain in existence as long as the comment is needed. **GETCOMMENT** helps out by changing the comment pointer to always point at the most recent file that the comment lives on. However, if the user has been performing repeated **MAKEFILE**'s (page 17.10) in which differing functions have changed at each invocation of **MAKEFILE**, it is possible for the comment pointers in memory to be pointing at several versions of the same file, since a comment pointer is only updated when the function it lives in is prettyprinted, not when the function has been copied verbatim to the new file. This can be a problem for file systems that have a built-in limit on the number of versions of a given file that will be made before old versions are expunged. In such a case, the user should set the version retention count of any directories involved to be infinite. **GETCOMMENT** prints an error message if the file that the comment pointer points at has disappeared.

Similarly, one should be cognizant of comment pointers in sysouts, and be sure to retain any files thus pointed to.

When using comment pointers, the user should also not set **PRETTYFLG** (page 26.48) to **NIL** or call **MAKEFILE** with option **FAST**, since this will prevent functions from being prettyprinted, and hence not get the text of the comment copied into the new file.

If the user changes the value of **COMMENTFLG** but still wishes to use the comment pointer feature, the new **COMMENTFLG** should be given the same read-macro definition in **FILERDTBL** as * has, and the same entry be put on **PRETTYPRINTMACROS**. For example, if **COMMENTFLG** is reset to be ";", then **(SETSYNTAX ';**

'* **FILERDTBL)** should be performed, and (; . **PRINTCOMMENT)** added to **PRETTYPRINTMACROS**.

## 26.5.3 Converting Comments to Lower Case

This section is for users using terminals without lower case, who nevertheless would like their comments to be converted to lower case for more readable listings. If the second atom in a comment is %%, the text of the comment is converted to lower case so that it looks like English instead of Lisp. Note that comments are converted *only* when they are actually written to a file by **PRETTYPRINT**.

The algorithm for conversion to lower case is the following: If the first character in an atom is ↑, do not change the atom (but remove the ↑). If the first character is %, convert the atom to lower case. Note that the user must type %% as % is the escape character. If the atom (minus any trailing punctuation marks) is an Interlisp word (i.e., is a bound or free variable for the function containing the comment, or has a top level value, or is a defined function, or has a non-**NIL** property list), do not change it. Otherwise, convert the atom to lower case. Conversion only affects the upper case alphabet, i.e., atoms already converted to lower case are not changed if the comment is converted again. When converting, the first character in the comment and the first character following each period are left capitalized. After conversion, the comment is physically modified to be the lower case text minus the %% flag, so that conversion is thus only performed once (unless the user edits the comment inserting additional upper case text and another %% flag).

**LCASELST** [Variable]

Words on **LCASELST** will always be converted to lower case. **LCASELST** is initialized to contain words which are Interlisp functions but also appear frequently in comments as English words (**AND**, **EVERY**, **GET**, **GO**, **LAST**, **LENGTH**, **LIST**, etc.). Therefore, if one wished to type a comment including the lisp fuction **GO**, it would be necessary to type ↑**GO** in order that it might be left in upper case.

**UCASELST** [Variable]

Words on **UCASELST** (that do not appear on **LCASELST)** will be left in upper case. **UCASELST** is initialized to **NIL**.

**ABBREVLST** [Variable]

**ABBREVLST** is used to distinguish between abbreviations and words that end in periods. Normally, words that end in periods and occur more than halfway to the right margin cause carriage-returns. Furthermore, during conversion to lowercase, words ending in periods, except for those on **ABBREVLST**, cause the first character in the *next* word to be capitalized. **ABBREVLST** is initialized to the upper and lower case forms of **ETC.**, **I.E.**, and **E.G.**.

## 26.5.4 Special Prettyprint Controls

**PRETTYTABFLG** [Variable]

In order to save space on files, tabs are used instead of spaces for the inital spaces on each line, assuming that each tab corresponds to 8 spaces. This results in a reduction of file size by about 30%. Tabs are not used if **PRETTYTABFLG** is set to **NIL** (initially **T**).

**#RPARS** [Variable]

Controls the number of right parentheses necessary for square bracketing to occur. If **#RPARS = NIL**, no brackets are used. **#RPARS** is initialized to 4.

**FIRSTCOL** [Variable]

The starting column for comments. Comments run between **FIRSTCOL** and the line length set by **LINELENGTH** (page 25.11). If a word in a comment ends with a "." and is not on the list **ABBREVLST**, and the position is greater than halfway between **FIRSTCOL** and **LINELENGTH**, the next word in the comment begins on a new line. Also, if a list is encountered in a comment, and the position is greater than halfway, the list begins on a new line.

**PRETTYLCOM** [Variable]

If a comment has more than **PRETTYLCOM** elements (using **COUNT**), it is printed starting at column 10, instead of **FIRSTCOL**. Comments are also printed starting at column 10 if their second element is also a *, i.e., comments of the form **(* * --)**.

**#CAREFULCOLUMNS** [Variable]

In the interests of efficiency, **PRETTYPRINT** approximates the number of characters in each atom, rather than calling **NCHARS**, when computing how much will fit on a line. This procedure works satisfactorily in most cases. However, users with unusually long atoms in their programs, e.g., such as produced by **CLISPIFY**, may occasionlly encounter some glitches in the output produced by **PRETTYPRINT**. The value of **#CAREFULCOLUMNS** tells **PRETTYPRINT** how many columns (counting from the right hand margin) in which to actually compute **NCHARS** instead of approximating. Setting **#CAREFULCOLUMNS** to 20 or 30 will eliminate the glitches, although it will slow down **PRETTYPRINT** slightly. **#CAREFULCOLUMNS** is initially 0.

**(WIDEPAPER** ***FLG*****)** [Function]

**(WIDEPAPER T)** sets **FILELINELENGTH** (page 25.11), **FIRSTCOL**, and **PRETTYLCOM** to large values appropriate for pretty printing files to be listed on wide paper. **(WIDEPAPER)** restores these parameters to their initial values. **WIDEPAPER** returns the previous setting of *FLG*.

**PRETTYFLG** [Variable]

If **PRETTYFLG** is **NIL**, **PRINTDEF** uses **PRIN2** instead of prettyprinting. This is useful for producing a fast symbolic dump (see the **FAST** option of **MAKEFILE**, page 17.10). Note that the file loads the same as if it were prettyprinted. **PRETTYFLG** is initially set to **T**. **PRETTYFLG** should not be set to **NIL** if comment pointers (page 26.44) are being used.

**CLISPIFYPRETTYFLG** [Variable]

Used to inform **PRETTYPRINT** to call **CLISPIFY** on selected function definitions before printing them (see page 21.26).

**PRETTYPRINTMACROS** [Variable]

An association-list that enables the user to control the formatting of selected expressions. **CAR** of each expression being **PRETTYPRINT**ed is looked up on **PRETTYPRINTMACROS**, and if found, **CDR** of the corresponding entry is applied to the expression. If the result of this application is **NIL**, **PRETTYPRINT** ignores the expression; i.e., it prints nothing, assuming that the prettyprintmacro has done any desired printing. If the result of applying the prettyprint macro is non-**NIL**, the result is prettyprinted in the normal fashion. This gives the user the option of computing some other expression to be prettyprinted in its place.

Note: "prettyprinted in the normal fashion" includes processing prettyprint macros, unless the prettyprint macro returns a structure **EQ** to the one it was handed, in which case the potential recursion is broken.

**PRETTYPRINTYPEMACROS** [Variable]

A list of elements of the form **(***TYPENAME* **.** ***FN*****)**. For types other than lists and atoms, the type name of each datum to be prettyprinted is looked up on **PRETTYPRINTYPEMACROS**, and if found, the corresponding function is applied to the datum about to be printed, instead of simply printing it with **PRIN2**.

**PRETTYEQUIVLST** [Variable]

An association-list that tells **PRETTYPRINT** to treat a **CAR**-of-form the same as some other **CAR**-of-form. For example, if **(QLAMBDA . LAMBDA)** appears on **PRETTYEQUIVLST**, then expressions beginning with **QLAMBDA** are prettyprinted the same as **LAMBDA**s. Currently, **PRETTYEQUIVLST** only allows (i.e., supports in an interesting way) equivalences to forms that **PRETTYPRINT** internally handles. Equivalence to forms for which the user has specified a prettyprint macro should be made by adding further entries to **PRETTYPRINTMACROS**

**CHANGECHAR** [Variable]

If non-**NIL**, and **PRETTYPRINT** is printing to a file or display terminal, **PRETTYPRINT** prints **CHANGECHAR** in the right hand margin while printing those expressions marked by the editor as having been changed (see page 16.30). **CHANGECHAR** is initially **|**.

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# 27. GRAPHICS OUTPUT OPERATIONS

Streams are used as the basis for all I/O operations. Files are implemented as streams that can support character printing and reading operations, and file pointer manipulation. An image stream is a type of stream that also provides an interface for graphical operations. All of the operations that can applied to streams can be applied to image streams. For example, an image stream can be passed as the argument to **PRINT**, to print something on an image stream. In addition, special functions are provided to draw lines and curves and perform other graphical operations. Calling these functions on a stream that is not an image stream will generate an error.

## 27.1 Primitive Graphics Concepts

The Interlisp-D graphics system is based on manipulating bitmaps (rectangular arrays of pixels), positions, regions, and textures. These objects are used by all of the graphics functions.

### 27.1.1 Positions

A position denotes a point in an X,Y coordinate system. A **POSITION** is an instance of a record with fields **XCOORD** and **YCOORD** and is manipulated with the standard record package facilities. For example, **(create POSITION XCOORD ← 10 YCOORD ← 20)** creates a position representing the point (10,20).

**(POSITIONP** *X***)** [Function]

Returns *X* if *X* is a position; **NIL** otherwise.

### 27.1.2 Regions

A Region denotes a rectangular area in a coordinate system. Regions are characterized by the coordinates of their bottom left corner and their width and height. A **REGION** is a record with fields **LEFT**, **BOTTOM**, **WIDTH**, and **HEIGHT**. It can be manipulated with the standard record package facilities. There are access functions for the **REGION** record that return the **TOP** and **RIGHT** of the region.

The following functions are provided for manipulating regions:

**(CREATEREGION** *LEFT BOTTOM WIDTH HEIGHT***)** [Function]

Returns an instance of the **REGION** record which has *LEFT*, *BOTTOM*, *WIDTH* and *HEIGHT* as respectively its **LEFT**, **BOTTOM**, **WIDTH**, and **HEIGHT** fields.

Example: **(CREATEREGION 10 -20 100 200)** will create a region that denotes a rectangle whose width is 100, whose height is 200, and whose lower left corner is at the position (10,-20).

**(REGIONP** *X***)** [Function]

Returns *X* if *X* is a region, **NIL** otherwise.

**(INTERSECTREGIONS** *REGION*$_1$ *REGION*$_2$ ... *REGION*$_n$**)** [NoSpread Function]

Returns a region which is the intersection of a number of regions. Returns **NIL** if the intersection is empty.

**(UNIONREGIONS** *REGION*$_1$ *REGION*$_2$ ... *REGION*$_n$**)** [NoSpread Function]

Returns a region which is the union of a number of regions, i.e. the smallest region that contains all of them. Returns **NIL** if there are no regions given.

**(REGIONSINTERSECTP** *REGION1 REGION2***)** [Function]

Returns **T** if *REGION1* intersects *REGION2*. Returns **NIL** if they do not intersect.

**(SUBREGIONP** *LARGEREGION SMALLREGION***)** [Function]

Returns **T** if *SMALLREGION* is a subregion (is equal to or entirely contained in) *LARGEREGION*; otherwise returns **NIL**.

**(EXTENDREGION** *REGION INCLUDEREGION***)** [Function]

Changes (destructively modifies) the region *REGION* so that it includes the region *INCLUDEREGION*. It returns *REGION*.

**(MAKEWITHINREGION** *REGION LIMITREGION***)** [Function]

Changes (destructively modifies) the left and bottom of the region *REGION* so that it is within the region *LIMITREGION*, if possible. If the dimension of *REGION* are larger than *LIMITREGION*, *REGION* is moved to the lower left of *LIMITREGION*. If *LIMITREGION* is **NIL**, the value of the variable **WHOLEDISPLAY** (the screen region) is used. **MAKEWITHINREGION** returns the modified *REGION*.

**(INSIDEP** *REGION POSORX Y***)** [Function]

If *POSORX* and *Y* are numbers, it returns **T** if the point (*POSORX,Y*) is inside of *REGION*. If *POSORX* is a **POSITION**, it returns **T** if *POSORX* is inside of *REGION*. If *REGION* is a **WINDOW**, the window's interior region in window coordinates is used. Otherwise, it returns **NIL**.

## 27.1.3 Bitmaps

The display primitives manipulate graphical images in the form of bitmaps. A bitmap is a rectangular array of "pixels," each of which is an integer representing the color of one point in the bitmap image. A bitmap is created with a specific number of bits allocated for each pixel. Most bitmaps used for the display screen use one bit per pixel, so that at most two colors can be represented. If a pixel is 0, the corresponding location on the image is white. If a pixel is 1, its location is black. This interpretation can be changed for the display screen with the function **VIDEOCOLOR** (page 30.23). Bitmaps with more than one bit per pixel are used to represent color or grey scale images. Bitmaps use a positive integer coordinate system with the lower left corner pixel at coordinate (0,0). Bitmaps are represented as instances of the datatype **BITMAP**. Bitmaps can be saved on files with the **VARS** file package command (page 17.35).

**(BITMAPCREATE** *WIDTH HEIGHT BITSPERPIXEL***)** [Function]

Creates and returns a new bitmap which is *WIDTH* pixels wide by *HEIGHT* pixels high, with *BITSPERPIXEL* bits per pixel. If *BITSPERPIXEL* is **NIL**, it defaults to 1.

**(BITMAPP** *X***)** [Function]

Returns *X* if *X* is a bitmap, **NIL** otherwise.

**(BITMAPWIDTH** *BITMAP***)** [Function]

Returns the width of *BITMAP* in pixels.

**(BITMAPHEIGHT** *BITMAP***)** [Function]

Returns the height of *BITMAP* in pixels.

**(BITSPERPIXEL** *BITMAP***)** [Function]

Returns the number of bits per pixel of *BITMAP*.

**(BITMAPBIT** *BITMAP X Y NEWVALUE***)** [Function]

If *NEWVALUE* is between 0 and the maximum value for a pixel in *BITMAP*, the pixel (*X,Y*) is changed to *NEWVALUE* and the old value is returned. If *NEWVALUE* is **NIL**, *BITMAP* is not changed but the value of the pixel is returned. If *NEWVALUE* is anything else, an error is generated. If *(X,Y)* is outside the limits of *BITMAP*, 0 is returned and no pixels are changed. *BITMAP* can also be a window or display stream. Note: non-window image streams are "write-only"; the *NEWVALUE* argument must be non-**NIL**.

**(BITMAPCOPY** *BITMAP***)** [Function]

Returns a new bitmap which is a copy of *BITMAP* (same dimensions, bits per pixel, and contents).

**(EXPANDBITMAP** *BITMAP WIDTHFACTOR HEIGHTFACTOR***)** [Function]

Returns a new bitmap that is *WIDTHFACTOR* times as wide as *BITMAP* and *HEIGHTFACTOR* times as high. Each pixel of *BITMAP* is copied into a *WIDTHFACTOR* times *HEIGHTFACTOR* block of pixels. If **NIL**, *WIDTHFACTOR* defaults to 4, *HEIGHTFACTOR* to 1.

**(SHRINKBITMAP** *BITMAP WIDTHFACTOR HEIGHTFACTOR DESTINATIONBITMAP***)** [Function]

Returns a copy of *BITMAP* that has been shrunken by *WIDTHFACTOR* and *HEIGHTFACTOR* in the width and height, respectively. If **NIL**, *WIDTHFACTOR* defaults to 4, *HEIGHTFACTOR* to 1. If *DESTINATIONBITMAP* is not provided, a bitmap that is 1/*WIDTHFACTOR* by 1/*HEIGHTFACTOR* the size of *BITMAP* is created and returned. *WIDTHFACTOR* and *HEIGHTFACTOR* must be positive integers.

**(PRINTBITMAP** *BITMAP FILE***)** [Function]

Prints the bitmap *BITMAP* on the file *FILE* in a format that can be read back in by **READBITMAP**.

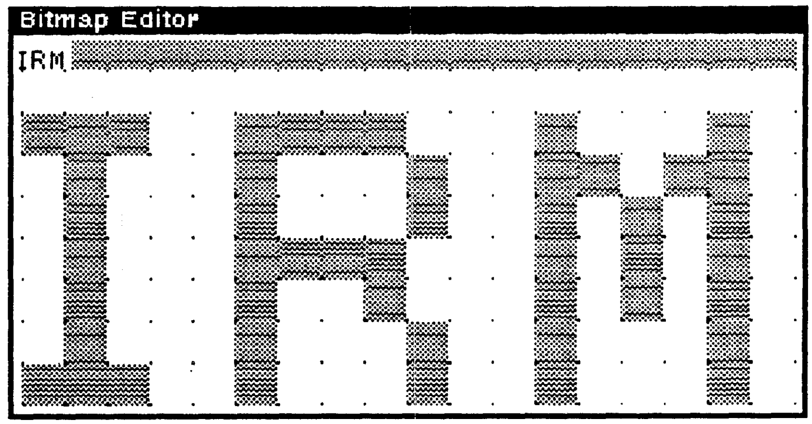
**(READBITMAP** *FILE***)** [Function]

Creates a bitmap by reading an expression (written by **PRINTBITMAP**) from the file *FILE*.

**(EDITBM** *BMSPEC***)** [Function]

**EDITBM** provides an easy-to-use interactive editing facility for various types of bitmaps. If *BMSPEC* is a bitmap, it is edited. If *BMSPEC* is an atom whose value is a bitmap, its value is edited. If *BMSPEC* is **NIL**, **EDITBM** asks for dimensions and creates a bitmap. If *BMSPEC* is a region, that portion of the screen bitmap is used. If *BMSPEC* is a window, it is brought to the top and its contents edited.

**EDITBM** sets up the bitmap being edited in an editing window. The editing window has two major areas: a gridded edit area in the lower part of the window and a display area in the upper left part. In the edit area, the left button will add points, the middle button will erase points. The right button provides access to the normal window commands to reposition and reshape the window. The actual size bitmap is shown in the display area. For example, the following is a picture of the bitmap editing window editing a eight-high by eighteen-wide bitmap:




If the bitmap is too large to fit in the edit area, only a portion will be editable. This portion can be changed by scrolling both up and down in the left margin and left and right in the bottom margin. Pressing the middle button while in the display area will bring up a menu that allows global placement of the portion of the bitmap being edited. To allow more of the bitmap to be editing at once, the window can be reshaped to make it larger or the **GridSize←** command described below can be used to reduce the size of a bit in the edit area.

The bitmap editing window can be reshaped to provide more or less room for editing. When this happens, the space allocated to the editing area will be changed to fit in the new region.

Whenever the left or middle button is down and the cursor is not in the edit area, the section of the display of the bitmap that is currently in the edit area is complemented. Pressing the left button while not in the edit region will put the lower left 16 x 16 section of the bitmap into the cursor for as long as the left button is held down.

Pressing the middle button while not in either the edit area or the display area (i.e. while in the grey area in the upper right or in the title) will bring up a command menu. There are commands to stop editing, to restore the bitmap to its initial state and to clear the bitmap. Holding the middle button down over a command will result in an explanatory message being printed in the prompt window. The commands are described below:

**Paint** Puts the current bitmap into a window and call the window **PAINT** command on it. The **PAINT** command implements drawing with various brush sizes and shapes but only on an actual sized bitmap. The **PAINT** mode is left by pressing the **RIGHT** button and selecting the **QUIT** command from the menu. At this point, you will be given a choice of whether or not the changes you made while in **PAINT** mode should be made to the current bitmap.

**ShowAsTile** Tesselates the current bitmap in the upper part of the window. This is useful for determining how a bitmap will look if it were made the display background (using the function **CHANGEBACKGROUND**). Note: The tiled display will not automatically change as the bitmap changes; to update it, use the **ShowAsTile** command again.

**Grid,On/Off** Turns the editing grid display on or off.

**GridSize←** Allows specification of the size of the editing grid. Another menu will appear giving a choice of several sizes. If one is selected, the editing portion of the bitmap editor will be redrawn using the selected grid size, allowing more or less of the bitmap to be edited without scrolling. The original size is chosen hueristically and is typically about 8. It is particularly useful when editing large bitmaps to set the edit grid size smaller than the original.

**Reset** Sets all or part of the bitmap to the contents it had when **EDITBM** was called. Another menu will appear giving a choice between resetting the entire bitmap or just the portion that is in the edit area. The second menu also acts as a confirmation, since not selecting one of the choices on this menu results in no action being taken.

**Clear** Sets all or part of the bitmap to 0. As with the **Reset** command, another menu gives a choice between clearing the entire bitmap or just the portion that is in the edit area.

**Cursor←** Sets the cursor to the lower left part of the bitmap. This prompts the user to specify the cursor "hot spot" (see page 30.14) by clicking in the lower left corner of the grid.

**OK** Copies the changed image into the original bitmap, stops the bitmap editor and closes the edit windows. The changes the bitmap editor makes during the interaction occur on a copy of the original bitmap. Unless the bitmap editor is exited via **OK**, no changes are made in the original.

**Stop** Stops the bitmap editor without making any changes to the original bitmap.

## 27.1.4 Textures

A Texture denotes a pattern of gray which can be used to (conceptually) tessellate the plane to form an infinite sheet of gray. It is currently either a 4 by 4 pattern or a 16 by *N* (*N* < = 16) pattern. Textures are created from bitmaps using the following function:

**(CREATETEXTUREFROMBITMAP** *BITMAP***)** [Function]

Returns a texture object that will produce the texture of *BITMAP*. If *BITMAP* is too large, its lower left portion is used. If *BITMAP* is too small, it is repeated to fill out the texture.

**(TEXTUREP** *OBJECT***)** [Function]

Returns *OBJECT* if it is a texture; **NIL** otherwise.

The functions which accept textures (**TEXTUREP**, **BITBLT**, **DSPTEXTURE**, etc.) also accept bitmaps up to 16 bits wide by 16 bits high as textures. When a region is being filled with a bitmap texture, the texture is treated as if it were 16 bits wide (if less, the rest is filled with white space).

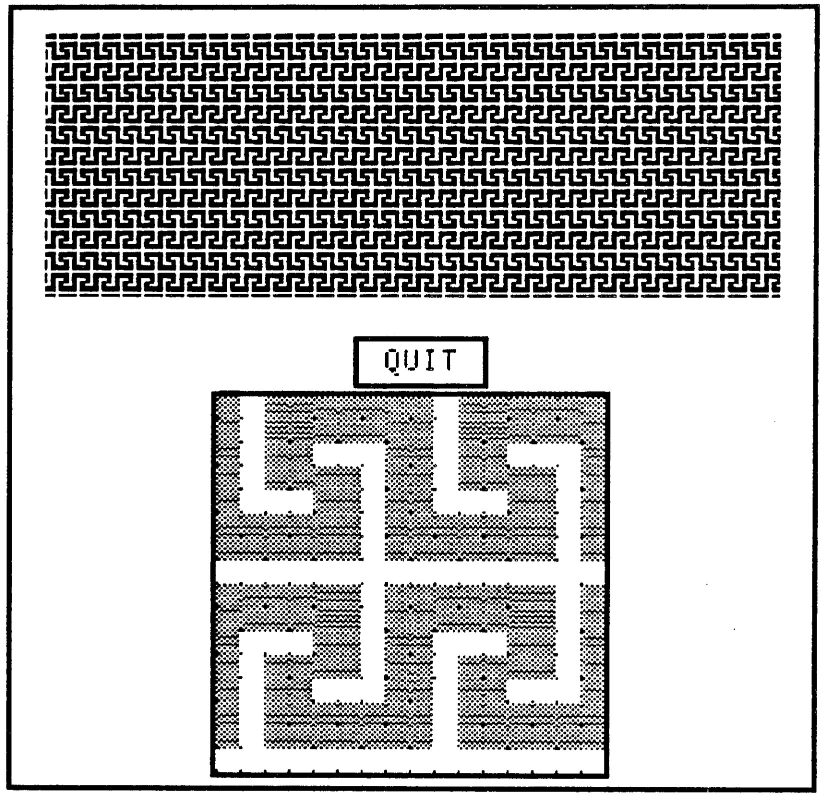
The common textures white and black are available as system constants **WHITESHADE** and **BLACKSHADE**. The global variable **GRAYSHADE** is used by many system facilities as a background gray shade and can be set by the user.

**(EDITSHADE** *SHADE***)** [Function]

Opens a window that allows the user to edit textures. Textures can be either small (4 by 4) patterns or large (16 by 16). In the edit area, the left button adds bits to the shade and the middle button erases bits from the shade. The top part of the window is painted with the current texture whenever all mouse keys are released. Thus it is possible to directly compare two textures that differ by more than one pixel by holding a mouse key down until all changes are made. When the "quit" button is selected, the texture being edited is returned.

If *SHADE* is a texture object, **EDITSHADE** starts with it. If *SHADE* is **T**, it starts with a large (16 by 16) white texture. Otherwise, it starts with **WHITESHADE**.

The following is a picture of the texture editor, editing a large (16 by 16) pattern:




## 27.2 Opening Image Streams

An image stream is an output stream which "knows" how to process graphic commands to a graphics output device. Besides accepting the normal character-output functions (**PRINT**, etc.), an image stream can also be passed as an argument to functions to draw curves, to print characters in multiple fonts, and other graphics operations.

Each image stream has an "image stream type," a litatom that specifies the type of graphic output device that the image stream is processing graphics commands for. Currently, the built-in image stream types are **DISPLAY** (for the display screen), **INTERPRESS** (for Interpress format printers), and **PRESS** (for Press format printers). There are also library packages available that define image stream types for the IRIS display, 4045 printer, FX-80 printer, C150 printer, etc.

Image streams to the display (display streams) interpret graphics commands by immediately executing the appropriate operations to cause the desired image to appear on the display screen. Image streams for hardcopy devices such as Interpress printers interpret the graphic commands by saving information in a file, which can later be sent to the printer.

Note: Not all graphics operations can be properly executed for all image stream types. For example, **BITBLT** may not be supported to all printers. This functionality is still being developed, but even in the long run some operations may be beyond the physical or logical capabilities of some devices or image file formats. In these cases, the stream will approximate the specified image as best it can.

**(OPENIMAGESTREAM** *FILE IMAGETYPE OPTIONS***)** [Function]

Opens and returns an image stream of type *IMAGETYPE* on a destination specified by *FILE*. If *FILE* is a file name on a normal file storage device, the image stream will store graphics commands on the specified file, which can be transmitted to a printer by explicit calls to **LISTFILES** and **SEND.FILE.TO.PRINTER**. If *IMAGETYPE* is **DISPLAY**, then the user is prompted for a window to open. *FILE* in this case will be used as the title of the window.

If *FILE* is a file name on the **LPT** device, this indicates that the graphics commands should be stored in a temporary file, and automatically sent to the printer when the image stream is closed by **CLOSEF**. *FILE* = **NIL** is equivalent to *FILE* = **{LPT}**. File names on the **LPT** device are of the form **{LPT}***PRINTERNAME.TYPE*, where *PRINTERNAME*, *TYPE*, or both may be omitted. *PRINTERNAME* is the name of the particular printer to which the file will be transmitted on closing; it defaults to the first printer on **DEFAULTPRINTINGHOST** that can print *IMAGETYPE* files. The *TYPE* extension supplies the value of *IMAGETYPE* when it is defaulted (see below). **OPENIMAGESTREAM** will generate an error if the specified printer does not accept the kind of file specified by *IMAGETYPE*.

If *IMAGETYPE* is **NIL**, the image type is inferred from the extension field of *FILE* and the **EXTENSIONS** properties in the list **PRINTFILETYPES** (see page 29.6). Thus, the extensions **IP**, **IPR**, and **INTERPRESS** indicate Interpress format, and the extension **PRESS** indicates Press format. If *FILE* is a printer file with no extension (of the form **{LPT}***PRINTERNAME*), then *IMAGETYPE* will be the type that the indicated printer can print. If *FILE* has no extension but is not on the printer device **{LPT}**, then *IMAGETYPE* will default to the type accepted by the first printer on **DEFAULTPRINTINGHOST**.

*OPTIONS* is a list in property list format, **(***PROP1 VAL1 PROP2 VAL2* **—)**, used to specify certain attributes of the image stream; not all attributes are meaningful or interpreted by all types of image streams. Acceptable properties are:

**REGION** Value is the region on the page (in stream scale units, 0,0 being the lower-left corner of the page) that text will fill up. It establishes the initial values for **DSPLEFTMARGIN**,

**DSPRIGHTMARGIN**, **DSPBOTTOMMARGIN** (the point at which carriage returns cause page advancement) and **DSPTOPMARGIN** (where the stream is positioned at the beginning of a new page).

If this property is not given, the value of the variable **DEFAULTPAGEREGION**, is used.

**FONTS** Value is a list of fonts that are expected to be used in the image stream. Some image streams (e.g. Interpress) are more efficient if the expected fonts are specified in advance, but this is not necessary. The first font in this list will be the initial font of the stream, otherwise the default font for that image stream type will be used.

**HEADING** Value is the heading to be placed automatically on each page. **NIL** means no heading.

Examples: Suppose that **Tremor:** is an Interpress printer, **Quake** is a Press printer, and **DEFAULTPRINTINGHOST** is **(Tremor: Quake)**:

**(OPENIMAGESTREAM)** returns an Interpress image stream on printer **Tremor:**.

**(OPENIMAGESTREAM NIL 'PRESS)** returns a Press stream on **Quake**.

**(OPENIMAGESTREAM '{LPT}.INTERPRESS)** returns an Interpress stream on **Tremor:**.

**(OPENIMAGESTREAM '{CORE}FOO.PRESS)** returns a Press stream on the file **{CORE}FOO.PRESS**.

**(IMAGESTREAMP** *X IMAGETYPE***)** [NoSpread Function]

Returns *X* (possibly coerced to a stream) if it is an output image stream of type *IMAGETYPE* (or of any type if *IMAGETYPE* = **NIL**), otherwise **NIL**.

**(IMAGESTREAMTYPE** *STREAM***)** [Function]

Returns the image stream type of *STREAM*.

**(IMAGESTREAMTYPEP** *STREAM TYPE***)** [Function]

Returns **T** if *STREAM* is an image stream of type *TYPE*.

## 27.3 Accessing Image Stream Fields

The following functions manipulate the fields of an image stream. These functions return the old value (the one being replaced). A value of **NIL** for the new value will return the current setting without changing it. These functions do not change any of the bits drawn on the image stream; they just affect future operations done on the image stream.

**(DSPCLIPPINGREGION** *REGION STREAM***)** [Function]

The clipping region is a region that limits the extent of characters printed and lines drawn (in the image stream's coordinate system). Initially set so that no clipping occurs.

Warning: For display streams, the window system maintains the clipping region during window operations. Users should be very careful about changing this field.

**(DSPFONT** *FONT STREAM***)** [Function]

The font field specifies the font (see page 27.25) used when printing characters to the image stream.

Note: **DSPFONT** determines its new font descriptor from *FONT* by the same coercion rules that **FONTPROP** and **FONTCREATE** use (page 27.26), with one additional possibility: If *FONT* is a list of the form (*PROP*$_1$ *VAL*$_1$ *PROP*$_2$ *VAL*$_2$ ...) where *PROP*$_1$ is acceptable as a font-property to **FONTCOPY** (page 27.28), then the new font is obtained by **(FONTCOPY (DSPFONT NIL** *STREAM***)** *PROP*$_1$ *VAL*$_1$ *PROP*$_2$ *VAL*$_2$ ...). For example, **(DSPFONT '(SIZE 12)** *STREAM***)** would change the font to the 12 point version of the current font, leaving all other font properties the same.

**(DSPTOPMARGIN** *YPOSITION STREAM***)** [Function]

The top margin is an integer that is the Y position after a new page (in the image stream's coordinate system). This function has no effect on windows.

**(DSPBOTTOMMARGIN** *YPOSITION STREAM***)** [Function]

The bottom margin is an integer that is the minimum Y position that characters will be printed by **PRIN1** (in the image stream's coordinate system). This function has no effect on windows.

**(DSPLEFTMARGIN** *XPOSITION STREAM***)** [Function]

The left margin is an integer that is the X position after an end-of-line (in the image stream's coordinate system). Initially the left edge of the clipping region.

**(DSPRIGHTMARGIN** *XPOSITION STREAM***)** [Function]

The right margin is an integer that is the maximum X position that characters will be printed by **PRIN1** (in the image stream's coordinate system). This is initially the position of the right edge of the window or page.

The line length of a window or image stream (as returned by **LINELENGTH**, page 25.11) is computed by dividing the distance between the left and right margins by the width of an uppercase "A" in the current font. The line length is changed whenever the font, left margin, or right margin are changed or whenever the window is reshaped.

**(DSPOPERATION** *OPERATION STREAM***)** [Function]

The operation is the default **BITBLT** operation (see page 27.15) used when printing or drawing on the image stream. One of **REPLACE, PAINT, INVERT**, or **ERASE**. Initially **REPLACE**. This is a meaningless operation for most printers which support the model that once dots are deposited on a page they cannot be removed.

**(DSPLINEFEED** *DELTAY STREAM***)** [Function]

The linefeed is an integer that specifies the Y increment for each linefeed, normally negative. Initially minus the height of the initial font.

**(DSPSCALE** *SCALE STREAM***)** [Function]

Returns the scale of the image stream *STREAM*, a number indicating how many units in the streams coordinate system correspond to one printer's point (1/72 of an inch). For example, **DSPSCALE** returns 1 for display streams, and 35.27778 for Interpress and Press streams (the number of micas per printer's point). In order to be device-independent, user graphics programs must either not specify position values absolutely, or must multiply absolute point quantities by the **DSPSCALE** of the destination stream. For example, to set the left margin of the Interpress stream **XX** to one inch, do

**(DSPLEFTMARGIN (TIMES 72 (DSPSCALE NIL XX)) XX)**

The *SCALE* argument to **DSPSCALE** is currently ignored. In a future release it will enable the scale of the stream to be changed under user control, so that the necessary multiplication will be done internal to the image stream interface. In this case, it would be possible to set the left margin of the Interpress stream **XX** to one inch by doing

**(DSPSCALE 1 XX)**
**(DSPLEFTMARGIN 72 XX)**

**(DSPSPACEFACTOR** *FACTOR STREAM***)** [Function]

The space factor is the amount by which to multiply the natural width of all following space characters on *STREAM*; this can be used for the justification of text. The default value is 1. For example, if the natural width of a space in *STREAM*'s current font is 12 units, and the space factor is set to two, spaces appear 24 units wide. The values returned by **STRINGWIDTH** and **CHARWIDTH** are also affected.

The following two functions only have meaning for image streams that can display color:

(**DSPCOLOR** *COLOR STREAM*) [Function]

Sets the default foreground color of *STREAM*. Returns the previous foreground color. If *COLOR* is **NIL**, it returns the current foreground color without changing anything. The default color is white

(**DSPBACKCOLOR** *COLOR STREAM*) [Function]

Sets the background color of *STREAM*. Returns the previous background color. If *COLOR* is **NIL**, it returns the current background color without changing anything. The default background color is black.

## 27.4 Current Position of an Image Stream

Each image stream has a "current position," which is a position (in the image stream's coordinate system) where the next printing operation will start from. The functions which print characters or draw on an image stream update these values appropriately. The following functions are used to explicitly access the current position of an image stream:

(**DSPXPOSITION** *XPOSITION STREAM*) [Function]

Returns the X coordinate of the current position of *STREAM*. If *XPOSITION* is non-**NIL**, the X coordinate is set to it (without changing the Y coordinate).

(**DSPYPOSITION** *YPOSITION STREAM*) [Function]

Returns the Y coordinate of the current position of *STREAM*. If *YPOSITION* is non-**NIL**, the Y coordinate is set to it (without changing the X coordinate).

(**MOVETO** *X Y STREAM*) [Function]

Changes the current position of *STREAM* to the point (*X,Y*).

**(RELMOVETO** *DX DY STREAM***)** [Function]

Changes the current position to the point (*DX*,*DY*) coordinates away from current position of *STREAM*.

**(MOVETOUPPERLEFT** *STREAM REGION***)** [Function]

Moves the current position to the beginning position of the top line of text. If *REGION* is non-**NIL**, it must be a **REGION** and the X position is changed to the left edge of *REGION* and the Y position changed to the top of *REGION* less the font ascent of *STREAM*. If *REGION* is **NIL**, the X coordinate is changed to the left margin of *STREAM* and the Y coordinate is changed to the top of the clipping region of *STREAM* less the font ascent of *STREAM*.

## 27.5 Moving Bits Between Bitmaps With BITBLT

**BITBLT** is the primitive function for moving bits from one bitmap to another, or from a bitmap to an image stream.

**(BITBLT** *SOURCE SOURCELEFT SOURCEBOTTOM DESTINATION DESTINATIONLEFT DESTINATIONBOTTOM WIDTH HEIGHT SOURCETYPE OPERATION TEXTURE CLIPPINGREGION***)** [Function]

Transfers a rectangular array of bits from *SOURCE* to *DESTINATION*. *SOURCE* can be a bitmap, or a display stream or window, in which case its associated bitmap is used. *DESTINATION* can be a bitmap or an arbitrary image stream.

*WIDTH* and *HEIGHT* define a pair of rectangles, one in each of the *SOURCE* and *DESTINATION* whose left, bottom corners are at, respectively, (*SOURCELEFT*, *SOURCEBOTTOM*) and (*DESTINATIONLEFT*, *DESTINATIONBOTTOM*). If these rectangles overlap the boundaries of either source or destination they are both reduced in size (without translation) so that they fit within their respective boundaries. If *CLIPPINGREGION* is non-**NIL** it should be a **REGION** and is interpreted as a clipping region within *DESTINATION*; clipping to this region may further reduce the defining rectangles. These (possibly reduced) rectangles define the source and destination rectangles for **BITBLT**.

The mode of transferring bits is defined by *SOURCETYPE* and *OPERATION*. *SOURCETYPE* and *OPERATION* specify whether the source bits should come from *SOURCE* or *TEXTURE*, and how these bits are combined with those of *DESTINATION*. *SOURCETYPE* and *OPERATION* are described further below.

*TEXTURE* is a texture, as described on page 27.6. **BITBLT** aligns the texture so that the upper-left pixel of the texture coincides with the upper-left pixel of the destination bitmap.

*SOURCELEFT*, *SOURCEBOTTOM*, *DESTINATIONLEFT*, and *DESTINATIONBOTTOM* default to 0. *WIDTH* and *HEIGHT* default to the width and height of the *SOURCE*. *TEXTURE* defaults to white. *SOURCETYPE* defaults to **INPUT**. *OPERATION* defaults to **REPLACE**. If *CLIPPINGREGION* is not provided, no additional clipping is done. **BITBLT** returns **T** if any bits were moved; **NIL** otherwise.

Note: If *SOURCE* or *DESTINATION* is a window or image stream, the remaining arguments are interpreted as values in the coordinate system of the window or image stream and the operation of **BITBLT** is translated and clipped accordingly. Also, if a window or image stream is used as the destination to **BITBLT**, its clipping region further limits the region involved.

*SOURCETYPE* specifies whether the source bits should come from the bitmap *SOURCE*, or from the texture *TEXTURE*. *SOURCETYPE* is interpreted as follows:

**INPUT** The source bits come from *SOURCE*. *TEXTURE* is ignored.

**INVERT** The source bits are the inverse of the bits from *SOURCE*. *TEXTURE* is ignored.

**TEXTURE** The source bits come from *TEXTURE*. *SOURCE*, *SOURCELEFT*, and *SOURCEBOTTOM* are ignored.

*OPERATION* specifies how the source bits (as specified by *SOURCETYPE*) are combined with the bits in *DESTINATION* and stored back into *DESTINATION*. *DESTINATION* is one of the following:

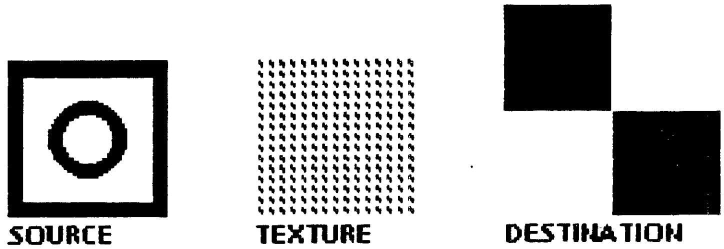
**REPLACE** All source bits (on or off) replace destination bits.

**PAINT** Any source bits that are on replace the corresponding destination bits. Source bits that are off have no effect. Does a logical OR between the source bits and the destination bits.

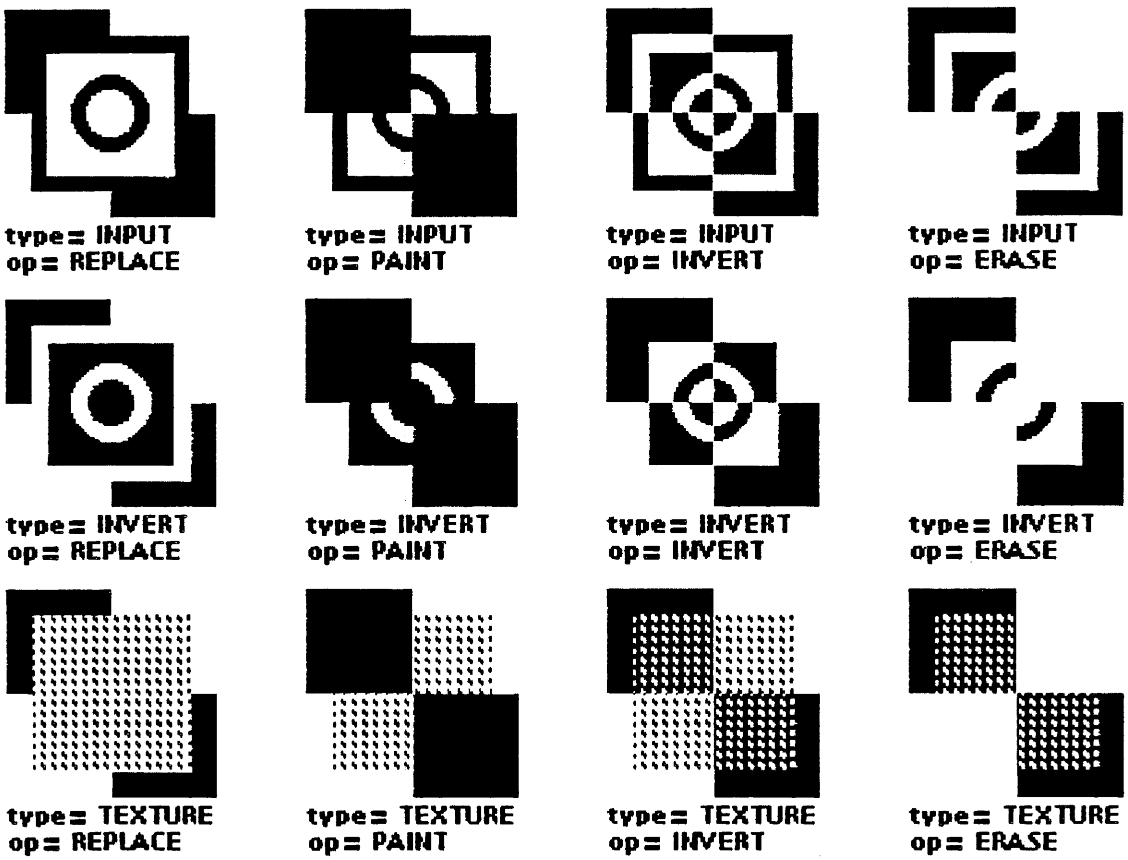
**INVERT** Any source bits that are on invert the corresponding destination bits. Does a logical XOR between the source bits and the destination bits.

**ERASE** Any source bits that are on erase the corresponding destination bits. Does a logical AND operation between the inverse of the source bits and the destination bits.

Different combinations of *SOURCETYPE* and *OPERATION* can be specified to achieve many different effects. Given the following bitmaps as the values of *SOURCE*, *TEXTURE*, and *DESTINATION*:




**BITBLT** would produce the results given below for the difference combinations of *SOURCETYPE* and *OPERATION* (assuming *CLIPPINGREGION*, *SOURCELEFT*, etc. are set correctly, of course):




(**BLTSHADE** *TEXTURE DESTINATION DESTINATIONLEFT DESTINATIONBOTTOM WIDTH HEIGHT OPERATION CLIPPINGREGION*) [Function]

**BLTSHADE** is the *SOURCETYPE* = **TEXTURE** case of **BITBLT**. It fills the specified region of the destination bitmap *DESTINATION* with the texture *TEXTURE*. *DESTINATION* can be a bitmap or image stream.

(**BITMAPIMAGESIZE** *BITMAP DIMENSION STREAM*) [Function]

Returns the size that *BITMAP* will be when **BITBLT**ed to *STREAM*, in *STREAM*'s units. *DIMENSION* can be one of **WIDTH**, **HEIGHT**, or **NIL**, in which case the dotted pair (*WIDTH* . *HEIGHT*) will be returned.

## 27.6 Drawing Lines

Interlisp-D provides several functions for drawing lines and curves on image streams. The line drawing functions are intended for interactive applications where efficiency is important. They do not allow the use of "brush" patterns, like the curve drawing functions, but (for display streams) they support drawing a line in **INVERT** mode, so redrawing the line will erase it. **DRAWCURVE** (page 27.19) can be used to draw lines using a brush.

(**DRAWLINE** *$X_1$ $Y_1$ $X_2$ $Y_2$ WIDTH OPERATION STREAM COLOR DASHING*) [Function]

Draws a straight line from the point ($X_1$,$Y_1$) to the point ($X_2$,$Y_2$) on the image stream *STREAM*. The position of *STREAM* is set to ($X_2$,$Y_2$). If $X_1$ equals $X_2$ and $Y_1$ equals $Y_2$, a point is drawn at ($X_1$,$Y_1$).

*WIDTH* is the width of the line, in the units of the device. If *WIDTH* is **NIL**, the default is 1.

*OPERATION* is the **BITBLT** operation (see page 27.15) used to draw the line. If *OPERATION* is **NIL**, the value of **DSPOPERATION** for the image stream is used.

*COLOR* is a color specification that determines the color used to draw the line for image streams that support color. If *COLOR* is **NIL**, the **DSPCOLOR** of *STREAM* is used.

*DASHING* is a list of positive integers that determines the dashing characteristics of the line. The line is drawn for the number of points indicated by the first element of the dashing list, is not drawn for the number of points indicated by the second element. The third element indicates how long it will be on again, and so forth. The dashing sequence is repeated from the beginning when the list is exhausted. If *DASHING* is **NIL**, the line is not dashed.

(**DRAWBETWEEN** *$POSITION_1$ $POSITION_2$ WIDTH OPERATION STREAM COLOR DASHING*) [Function]

Draws a line from the point *$POSITION_1$* to the point *$POSITION_2$* onto the destination bitmap of *STREAM*. The position of *STREAM* is set to *$POSITION_2$*.

(**DRAWTO** *X Y WIDTH OPERATION STREAM COLOR DASHING*) [Function]

Draws a line from the current position to the point (*X*,*Y*) onto the destination bitmap of *STREAM*. The position of *STREAM* is set to (*X*,*Y*).

**(RELDRAWTO** *DX DY WIDTH OPERATION STREAM COLOR DASHING***)** [Function]

Draws a line from the current position to the point (*DX*,*DY*) coordinates away onto the destination bitmap of *STREAM*. The position of *STREAM* is set to the end of the line. If *DX* and *DY* are both 0, nothing is drawn.

## 27.7 Drawing Curves

A curve is drawn by placing a brush pattern centered at each point along the curve's trajectory. A brush pattern is defined by its shape, size, and color. The predefined brush shapes are **ROUND**, **SQUARE**, **HORIZONTAL**, **VERTICAL**, and **DIAGONAL**; new brush shapes can be created using the **INSTALLBRUSH** function, described below. A brush size is an integer specifying the width of the brush in the units of the device. The color is a color specification, which is only used if the curve is drawn to an image stream that supports colors.

A brush is specified to the various drawing functions as a list of the form **(***SHAPE WIDTH COLOR***)**, for example **(SQUARE 2)** or **(VERTICAL 4 RED)**. A brush can also be specified as a positive integer, which is interpreted as a **ROUND** brush of that width. If a brush is a litatom, it is assumed to be a function which is called at each point of the curve's trajectory (with three arguments: the X-coordinate of the point, the Y-coordinate, and the image stream), and should do whatever image stream operations are necessary to draw each point. Finally, if a brush is specified as **NIL**, a **(ROUND 1)** brush is used as default.

The appearance of a curve is also determined by its dashing characteristics. Dashing is specified by a list of positive integers. If a curve is dashed, the brush is placed along the trajectory for the number of units indicated by the first element of the dashing list. The brush is *off*, not placed in the bitmap, for a number of units indicated by the second element. The third element indicates how long it will be on again, and so forth. The dashing sequence is repeated from the beginning when the list is exhausted. The units used to measure dashing are the units of the brush. For example, specifying the dashing as **(1 1)** with a brush of **(ROUND 16)** would put the brush on the trajectory, skip 16 points, and put down another brush. A curve is not dashed if the dashing argument to the drawing function is **NIL**.

The curve functions use the image stream's clipping region and operation. Most types of image streams only support the **PAINT** operation when drawing curves. When drawing to a display stream, the curve-drawing functions accept the operation **INVERT** if the brush argument is 1. For brushes larger than 1, these functions will use the **ERASE** operation instead of **INVERT**. For display streams, the curve-drawing functions treat the **REPLACE** operation the same as **PAINT**.

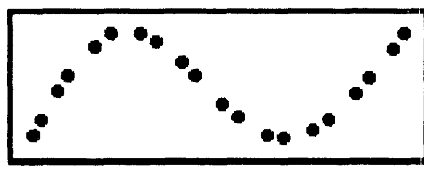
**(DRAWCURVE** *KNOTS CLOSED BRUSH DASHING STREAM***)** [Function]

Draws a "parametric cubic spline curve" on the image stream *STREAM*. *KNOTS* is a list of positions to which the curve will be fitted. If *CLOSED* is non-**NIL**, the curve will be closed; otherwise it ends at the first and last positions in *KNOTS*. *BRUSH* and *DASHING* are interpreted as described above.

For example,

**(DRAWCURVE '((10 . 10)(50 . 50)(100 . 10)(150 . 50))**
**NIL '(ROUND 5) '(1 1 1 2) XX)**

would draw a curve like the following on the display stream **XX**:



**(DRAWCIRCLE** *CENTERX CENTERY RADIUS BRUSH DASHING STREAM***)** [Function]

Draws a circle of radius *RADIUS* about the point (*CENTERX*,*CENTERY*) onto the image stream *STREAM*. *STREAM*'s position is left at (*CENTERX*,*CENTERY*). The other arguments are interpreted as described above.

**(DRAWELLIPSE** *CENTERX CENTERY SEMIMINORRADIUS SEMIMAJORRADIUS ORIENTATION BRUSH DASHING STREAM***)** [Function]

Draws an ellipse with a minor radius of *SEMIMINORRADIUS* and a major radius of *SEMIMAJORRADIUS* about the point (*CENTERX*,*CENTERY*) onto the image stream *STREAM*. *ORIENTATION* is the angle of the major axis in degrees, positive in the counterclockwise direction. *STREAM*'s position is left at (*CENTERX*,*CENTERY*). The other arguments are interpreted as described above.

New brush shapes can be defined using the following function:

**(INSTALLBRUSH** *BRUSHNAME BRUSHFN BRUSHARRAY***)** [Function]

Installs a new brush called *BRUSHNAME* with creation-function *BRUSHFN* and optional array *BRUSHARRAY*. *BRUSHFN* should be a function of one argument (a width), which returns a bitmap of the brush for that width. *BRUSHFN* will be called to create new instances of *BRUSHNAME*-type brushes; the sixteen smallest instances will be pre-computed and cached. "Hand-crafted" brushes can be supplied as the *BRUSHARRAY* argument.

Changing an existing brush can be done by calling **INSTALLBRUSH** with new *BRUSHFN* and/or *BRUSHARRAY*.

**(DRAWPOINT** *X Y BRUSH STREAM OPERATION***)** [Function]

Draws *BRUSH* centered around point (*X*, *Y*) on *STREAM*, using the operation *OPERATION*. *BRUSH* may be a bitmap or a brush.

## 27.8 Miscellaneous Drawing and Printing Operations

**(DSPFILL** *REGION TEXTURE OPERATION STREAM***)** [Function]

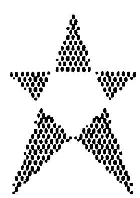
Fills *REGION* of the image stream *STREAM* (within the clipping region) with the texture *TEXTURE*. If *REGION* is **NIL**, the whole clipping region of *STREAM* is used. If *TEXTURE* or *OPERATION* is **NIL**, the values for *STREAM* are used.

**(FILLPOLYGON** *POINTS TEXTURE STREAM***)** [Function]

Fills in the polygon outlined by *POINTS* on the image stream *STREAM*, using the texture *TEXTURE*.

*POINTS* is a list of positions (page 27.1) determining the vertices of a closed polygon. **FILLPOLYGON** fills in this polygon with the texture *TEXTURE*. *POINTS* can also be a list whose elements are lists of positions, in which case each sublist describes a separate polygon to be filled.

Note: When filling a polygon, there is more than one way of dealing with the situation where two polygon sides intersect, or one polygon is fully inside the other. Currently, **FILLPOLYGON** to a display stream uses the "odd" fill rule, which means that intersecting polygon sides define areas that are filled or not filled somewhat like a checkerboard. For example, **(FILLPOLYGON '((125 . 125)(150 . 200)(175 . 125)(125 . 175)(175 . 175)) GRAYSHADE** *WINDOW***)** would produce a display something like this:

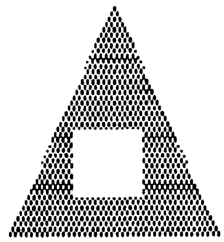


This fill convention also takes into account all polygons in *POINTS*, if it specifies multiple polygons. This can be used to put "holes" in filled polygons. For example,

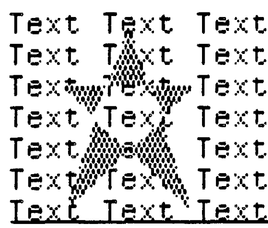
```
(FILLPOLYGON
 '( ((110 . 110)(150 . 200)(190 . 110))
   ((135 . 125)(160 . 125)(160 . 150)(135 . 150)) )
```

**GRAYSHADE** *WINDOW*)

will put a square hole in a triangular region:



Currently, **FILLPOLYGON** uses the "Replace" **BITBLT** operation (see page 27.15) to fill areas with the texture. However, any areas that are not filled are not changed. If there are "holes" in the filled polygon, this can be used to produce a "window" effect. For example, the following is the display produced by filling the star polygon (above) over a window full of text:




**(FILLCIRCLE** *CENTERX CENTERY RADIUS TEXTURE STREAM***)** [Function]

Fills in a circular area of radius *RADIUS* about the point (*CENTERX*,*CENTERY*) in *STREAM* with *TEXTURE*. *STREAM*'s position is left at (*CENTERX*,*CENTERY*).

**(DSPRESET** *STREAM***)** [Function]

Sets the X coordinate of *STREAM* to its left margin, sets its Y coordinate to the top of the clipping region minus the font ascent. For a display stream, this also fills its destination bitmap with its background texture.

**(DSPNEWPAGE** *STREAM***)** [Function]

Starts a new page. The X coordinate is set to the left margin, and the Y coordinate is set to the top margin plus the linefeed.

**(CENTERPRINTINREGION** *EXP REGION STREAM***)** [Function]

Prints *EXP* so that is it centered within *REGION* of the *STREAM*. If *REGION* is **NIL**, *EXP* will be centered in the clipping region of *STREAM*.

## 27.9 Drawing and Shading Grids

A grid is a partitioning of an arbitrary coordinate system (hereafter referred to as the "source system") into rectangles. This section describes functions that operate on grids. It includes functions to draw the outline of a grid, to translate between positions in a source system and grid coordinates (the coordinates of the rectangle which contains a given position), and to shade grid rectangles. A grid is defined by its "unit grid," a region (called a grid specification) which is the origin rectangle of the grid in terms of the source system. Its **LEFT** field is interpreted as the X-coordinate of the left edge of the origin rectangle, its **BOTTOM** field is the Y-coordinate of the bottom edge of the origin rectangle, its **WIDTH** is the width of the grid rectangles, and its **HEIGHT** is the height of the grid rectangles.

**(GRID** *GRIDSPEC WIDTH HEIGHT BORDER STREAM GRIDSHADE***)** [Function]

Outlines the grid defined by *GRIDSPEC* which is *WIDTH* rectangles wide and *HEIGHT* rectangles high on *STREAM*. Each box in the grid has a border within it that is *BORDER* points on each side; so the resulting lines in the grid are 2**BORDER* thick. If *BORDER* is the atom **POINT**, instead of a border the lower left point of each grid rectangle will be turned on. If *GRIDSHADE* is non-**NIL**, it should be a texture and the border lines will be drawn using that texture.

**(SHADEGRIDBOX** *X Y SHADE OPERATION GRIDSPEC GRIDBORDER STREAM***)** [Function]

Shades the grid rectangle (*X,Y*) of *GRIDSPEC* with texture *SHADE* using *OPERATION* on *STREAM*. *GRIDBORDER* is interpreted the same as for **GRID**.

The following two functions map from the X,Y coordinates of the source system into the grid X,Y coordinates:

**(GRIDXCOORD** *XCOORD GRIDSPEC***)** [Function]

Returns the grid X-coordinate (in the grid specified by *GRIDSPEC*) that contains the source system X-coordinate *XCOORD*.

**(GRIDYCOORD** *YCOORD GRIDSPEC***)** [Function]

Returns the grid Y-coordinate (in the grid specified by *GRIDSPEC*) that contains the source system Y-coordinate *YCOORD*.

The following two functions map from the grid X,Y coordinates into the X,Y coordinates of the source system:

**(LEFTOFGRIDCOORD** *GRIDX GRIDSPEC***)** [Function]

Returns the source system X-coordinate of the left edge of a grid rectangle at grid X-coordinate *GRIDX* (in the grid specified by *GRIDSPEC*).

**(BOTTOMOFGRIDCOORD** *GRIDY GRIDSPEC***)** [Function]

Returns the source system Y-coordinate of the bottom edge of a grid rectangle at grid Y-coordinate *GRIDY* (in the grid specified by *GRIDSPEC*).

## 27.10 Display Streams

Display streams (image streams of type **DISPLAY**) are used to control graphic output operations to a bitmap, known as the "destination" bitmap of the display stream. For each window on the screen, there is an associated display stream which controls graphics operations to a specific part of the screen bitmap. Any of the functions that take a display stream will also take a window, and use the associated display stream. Display streams can also have a destination bitmap that is not connected to any window or display device.

**(DSPCREATE** *DESTINATION***)** [Function]

Creates and returns a display stream. If *DESTINATION* is specified, it is used as the destination bitmap, otherwise the screen bitmap is used.

**(DSPDESTINATION** *DESTINATION DISPLAYSTREAM***)** [Function]

Returns the current destination bitmap for *DISPLAYSTREAM*, setting it to *DESTINATION* if non-**NIL**. *DESTINATION* can be either the screen bitmap, or an auxilliary bitmap in order to construct figures, possibly save them, and then display them in a single operation.

Warning: The window system maintains the destination of a window's display stream. Users should be very careful about changing this field.

**(DSPXOFFSET** *XOFFSET DISPLAYSTREAM***)** [Function]

**(DSPYOFFSET** *YOFFSET DISPLAYSTREAM***)** [Function]

Each display stream has its own coordinate system, separate from the coordinate system of its destination bitmap. Having the coordinate system local to the display stream allows objects to be displayed at different places by translating the display stream's coordinate system relative to its destination bitmap. This local coordinate system is defined by the X offset and Y offset.

**DSPXOFFSET** returns the current X offset for *DISPLAYSTREAM*, the X origin of the display stream's coordinate system in the destination bitmap's coordinate system. It is set to *XOFFSET* if non-**NIL**.

**DSPYOFFSET** returns the current Y offset for *DISPLAYSTREAM*, the Y origin of the display stream's coordinate system in the destination bitmap's coordinate system. It is set to *YOFFSET* if non-**NIL**.

The X offset and Y offset for a display stream are both initially 0 (no X or Y-coordinate translation).

Warning: The window system maintains the X and Y offset of a window's display stream. Users should be very careful about changing these fields.

**(DSPTEXTURE** *TEXTURE DISPLAYSTREAM***)** [Function]

Returns the current texture used as the background pattern for *DISPLAYSTREAM*. It is set to *TEXTURE* if non-**NIL**. Initially the value of **WHITESHADE**.

**(DSPSOURCETYPE** *SOURCETYPE DISPLAYSTREAM***)** [Function]

Returns the current **BITBLT** sourcetype used when printing characters to the display stream (see page 27.15). It is set to **SOURCETYPE**, if non-**NIL**. Must be either **INPUT** or **INVERT**. Initially **INPUT**.

**(DSPSCROLL** *SWITCHSETTING DISPLAYSTREAM***)** [Function]

Returns the current value of the "scroll flag," a flag that determines the scrolling behavior of the display stream; either **ON** or **OFF**. If **ON**, the bits in the display streams's destination bitmap are moved after any linefeed that moves the current position out of the destination bitmap. Any bits moved out of the current clipping region are lost. Does not adjust the X offset, Y offset, or clipping region of the display stream. Initially **OFF**.

Sets the scroll flag to *SWITCHSETTING*, if non-**NIL**.

Note: The word "scrolling" also describes the use of "scroll bars" on the left and bottom of a window to move an object displayed in a window. This feature is described on page 28.23.

Each window has an associated display stream. To get the window of a particular display stream, use **WFROMDS**:

**(WFROMDS** ***DISPLAYSTREAM DONTCREATE*****)** [Function]

Returns the window associated with *DISPLAYSTREAM*, creating a window if one does not exist (and *DONTCREATE* is **NIL**). Returns **NIL** if the destination of *DISPLAYSTREAM* is not a screen bitmap that supports a window system.

If *DONTCREATE* is non-**NIL**, **WFROMDS** will never create a window, and returns **NIL** if *DISPLAYSTREAM* does not have an associated window.

**TTYDISPLAYSTREAM** calls **WFROMDS** with *DONTCREATE* = **T**, so it will not create a window unnecessarily. Also, if **WFROMDS** does create a window, it calls **CREATEW** with *NOOPENFLG* = **T**.

**(DSPBACKUP** ***WIDTH DISPLAYSTREAM*****)** [Function]

Backs up *DISPLAYSTREAM* over a character which is *WIDTH* screen points wide. **DSPBACKUP** fills the backed over area with the display stream's background texture and decreases the X position by *WIDTH*. If this would put the X position less than *DISPLAYSTREAM*'s left margin, its operation is stopped at the left margin. It returns **T** if any bits were written, **NIL** otherwise.

## 27.12 Fonts

A font is the collection of images that are printed or displayed when characters are output to a graphic output device. Some simple displays and printers can only print characters using one font. Bitmap displays and graphic printers can print characters using a large number of fonts.

Fonts are identified by a distinctive style or family (such as Modern or Classic), a size (such as 10 points), and a face (such as bold or italic). Fonts also have a rotation that indicates the orientation of characters on the screen or page. A normal horizontal font (also called a portrait font) has a rotation of 0; the rotation of a vertical (landscape) font is 90 degrees. While any combination can be specified, in practice the user will find that only certain combinations of families, sizes, faces, and rotations are available for any graphic output device.

To specify a font to the functions described below, a **FAMILY** is represented by a literal atom, a **SIZE** by a positive integer, and a **FACE** by a three-element list of the form **(WEIGHT SLOPE EXPANSION)**. **WEIGHT**, which indicates the thickness of the characters, can be **BOLD**, **MEDIUM**, or **LIGHT**; **SLOPE** can be **ITALIC** or **REGULAR**; and **EXPANSION** can be **REGULAR**, **COMPRESSED**, or **EXPANDED**, indicating how spread out the characters are. For convenience, faces may also be specified by three-character atoms, where each character is the first letter of the corresponding field. Thus, **MRR** is a synonym for **(MEDIUM REGULAR REGULAR)**. In addition, certain common face combinations may be indicated by special literal atoms:

**STANDARD = (MEDIUM REGULAR REGULAR) = MRR**

**ITALIC = (MEDIUM ITALIC REGULAR) = MIR**

**BOLD = (BOLD REGULAR REGULAR) = BRR**

**BOLDITALIC = (BOLD ITALIC REGULAR) = BIR**

Interlisp represents all the information related to a font in an object called a font descriptor. Font descriptors contain the family, size, etc. properties used to represent the font. In addition, for each character in the font, the font descriptor contains width information for the character and (for display fonts) a bitmap containing the picture of the character.

The font functions can take fonts specified in a variety of different ways. **DSPFONT, FONTCREATE, FONTCOPY**, etc. can be applied to font descriptors, "font lists" such as **'(MODERN 10)**, image streams (coerced to its current font), or windows (coerced to the current font of its display stream). The printout command "**.FONT**" (page 25.27) will also accept fonts specified in any of these forms.

**(FONTCREATE** *FAMILY SIZE FACE ROTATION DEVICE NOERRORFLG CHARSET***)** [Function]

Returns a font descriptor for the specified font. *FAMILY* is a litatom specifying the font family. *SIZE* is an integer indicating the size of the font in points. *FACE* specifies the face characteristics in one of the formats listed above; if *FACE* is **NIL**, **STANDARD** is used. *ROTATION*, which specifies the orientation of the font, is 0 (or **NIL**) for a portrait font and 90 for a landscape font. *DEVICE* indicates the output device for the font, and can be any image stream type (page 27.8), such as **DISPLAY**, **INTERPRESS**, etc. *DEVICE* may also be an image stream, in which case the type of the stream determines the font device. *DEVICE* defaults to **DISPLAY**.

The *FAMILY* argument to **FONTCREATE** may also be a list, in which case it is interpreted as a font-specification quintuple, a list of the form (*FAMILY SIZE FACE ROTATION DEVICE*). Thus, **(FONTCREATE '(GACHA 10 BOLD))** is equivalent to **(FONTCREATE 'GACHA 10 'BOLD)**. *FAMILY* may also be a font descriptor, in which case that descriptor is simply returned.

If a font descriptor has already been created for the specified font, **FONTCREATE** simply returns it. If it has not been created, **FONTCREATE** has to read the font information from a font file that contains the information for that font. The name of an appropriate font file, and the algorithm for searching depends on the device that the font is for, and is described in more detail below. If an appropriate font file is found, it is read into a font descriptor. If no file is found, for **DISPLAY** fonts **FONTCREATE** looks for fonts with less face information and fakes the remaining faces (such as by doubling the bit pattern of each character or slanting it). For hardcopy printer fonts, there is no acceptable faking algorithm.

If no acceptable font is found, the action of **FONTCREATE** is determined by *NOERRORFLG*. If *NOERRORFLG* is **NIL**, it generates a **FONT NOT FOUND** error with the offending font specification; otherwise, **FONTCREATE** returns **NIL**.

*CHARSET* is the character set which will be read to create the font. Defaults to 0. For more information on character sets, see NS Characters, page 2.12.

**(FONTP *X*)** [Function]

Returns *X* if *X* is a font descriptor; **NIL** otherwise.

**(FONTPROP *FONT PROP*)** [Function]

Returns the value of the *PROP* property of font *FONT*. The following font properties are recognized:

**FAMILY** The style of the font, represented as a literal atom, such as **CLASSIC** or **MODERN**.

**SIZE** A positive integer giving the size of the font, in printer's points (1/72 of an inch).

**WEIGHT** The thickness of the characters; one of **BOLD**, **MEDIUM**, or **LIGHT**.

**SLOPE** The "slope" of the characters in the font; one of **ITALIC** or **REGULAR**.

**EXPANSION** The extent to which the characters in the font are spread out; one of **REGULAR**, **COMPRESSED**, or **EXPANDED**. Most available fonts have **EXPANSION = REGULAR**.

**FACE** A three-element list of the form **(*WEIGHT SLOPE EXPANSION*)**, giving all of the typeface parameters.

**ROTATION** An integer that gives the orientation of the font characters on the screen or page, in degrees. A normal horizontal font (also called a portrait font) has a rotation of 0; the rotation of a vertical (landscape) font is 90.

**DEVICE** The device that the font can be printed on; one of **DISPLAY**, **INTERPRESS**, etc.

**ASCENT** An integer giving the maximum height of any character in the font from its base line (the printing position). The top line will be at *BASELINE* + *ASCENT*-1.

**DESCENT** An integer giving the maximum extent of any character below the base line, such as the lower part of a "p". The bottom line of a character will be at *BASELINE*-*DESCENT*.

**HEIGHT** Equal to **ASCENT** + **DESCENT**.

**SPEC** The (*FAMILY SIZE FACE ROTATION DEVICE*) quintuple by which the font is known to Lisp.

**DEVICESPEC** The (*FAMILY SIZE FACE ROTATION DEVICE*) quintuple that identifies what will be used to represent the font on the display or printer. It will differ from the **SPEC** property only if an implicit coercion is done to approximate the specified font with one that actually exists on the device.

**SCALE** The units per printer's point (1/72 of an inch) in which the font is measured. For example, this is 35.27778 (the number of micas per printer's point) for Interpress fonts, which are measured in terms of micas.

**(FONTCOPY** *OLDFONT* $PROP_1$ $VAL_1$ $PROP_2$ $VAL_2$ ...**)** [NoSpread Function]

Returns a font descriptor that is a copy of the font *OLDFONT*, but which differs from *OLDFONT* in that *OLDFONT*'s properties are replaced by the specified properties and values. Thus, **(FONTCOPY** *FONT* **'WEIGHT 'BOLD 'DEVICE 'INTERPRESS)** will return a bold Interpress font with all other properties the same as those of *FONT*. **FONTCOPY** accepts the properties **FAMILY**, **SIZE**, **WEIGHT**, **SLOPE**, **EXPANSION**, **FACE**, **ROTATION**, and **DEVICE**. If the first property is a list, it is taken to be the $PROP_1$ $VAL_1$ $PROP_2$ $VAL_2$ ... sequence. Thus, **(FONTCOPY** *FONT* **'(WEIGHT BOLD DEVICE INTERPRESS))** is equivalent to the example above.

If the property **NOERROR** is specified with value non-**NIL**, **FONTCOPY** will return **NIL** rather than causing an error if the specified font cannot be created.

**(FONTSAVAILABLE** *FAMILY SIZE FACE ROTATION DEVICE CHECKFILESTOO?***)** [Function]

Returns a list of available fonts that match the given specification. *FAMILY*, *SIZE*, *FACE*, *ROTATION*, and *DEVICE* are the same as for **FONTCREATE**. Additionally, any of them can be the atom *, in which case all values of that field are matched.

If *CHECKFILESTOO?* is **NIL**, only fonts already loaded into virtual memory will be considered. If *CHECKFILESTOO?* is non-**NIL**, the font directories for the specified device will be searched. When checking font files, the *ROTATION* is ignored.

Note: The search is conditional on the status of the server which holds the font. Thus a file server crash may prevent **FONTCREATE** from finding a file that an earlier **FONTSAVAILABLE** returned.

Each element of the list returned will be of the form (*FAMILY SIZE FACE ROTATION DEVICE*).

Examples:

**(FONTSAVAILABLE 'MODERN 10 'MRR 0 'DISPLAY)**

will return **((MODERN 10 (MEDIUM REGULAR REGULAR) 0 DISPLAY))** if the regular Modern 10 font for the display is in virtual memory; **NIL** otherwise.

**(FONTSAVAILABLE '* 14 '* '* 'INTERPRESS T)**

will return a list of all the size 14 Interpress fonts, whether they are in virtual memory or in font files.

Warning: One must be careful when using the function **FONTSAVAILABLE** to determine what Press font files are available. For Press font families/faces, the font widths for different sizes are consistently scaled versions of the smallest font in the family/face. Therefore, instead of storing data about all of the sizes in the **FONTS.WIDTHS** file, only the widths for the font of *SIZE* = 1 are stored, and the other widths are calculated by scaling these widths up. This is signified in the **FONTS.WIDTHS** file by a font with *SIZE* = 0. Therefore, if **FONTSAVAILABLE** is called with *CHECKFILESTOO?* = T, and it finds such a "relative" font, it returns a font spec list with size of 0. For example,

```
←(FONTSAVAILABLE 'GACHA '* '* 0 'PRESS T)
((GACHA 0 (BOLD ITALIC REGULAR) 0 PRESS)
 (GACHA 0 (BOLD REGULAR REGULAR) 0 PRESS)
 (GACHA 0 (MEDIUM ITALIC REGULAR) 0 PRESS)
 (GACHA 0 (MEDIUM REGULAR REGULAR) 0 PRESS))
```

This indicates that Press files can be created with **GACHA** files of any size with faces **BIR**, **BRR**, **MIR**, and **MRR**. Of course, this doesn't guarantee that these fonts are available in all sizes on your printer.

**(SETFONTDESCRIPTOR** *FAMILY SIZE FACE ROTATION DEVICE FONT***)** [Function]

Indicates to the system that *FONT* is the font that should be associated with the *FAMILY SIZE FACE ROTATION DEVICE* characteristics. If *FONT* is **NIL**, the font associated with these characteristics is cleared and will be recreated the next time it is needed. As with **FONTPROP** and **FONTCOPY**, *FONT* is coerced to a font descriptor if it is not one already.

This functions is useful when it is desirable to simulate an unavailable font or to use a font with characteristics different from the interpretations provided by the system.

**(DEFAULTFONT** *DEVICE FONT*—**)** [Function]

Returns the font that would be used as the default (if **NIL** were specified as a font argument) for image stream type *DEVICE*. If *FONT* is a font descriptor, it is set to be the default font for *DEVICE*.

**(CHARWIDTH** *CHARCODE FONT***)** [Function]

*CHARCODE* is an integer that represents a valid character (as returned by **CHCON1**). Returns the amount by which an image stream's X-position will be incremented when the character is printed.

**(CHARWIDTHY** *CHARCODE FONT***)** [Function]

Like **CHARWIDTH**, but returns the Y component of the character's width, the amount by which an image stream's Y-position will be incremented when the character is printed. This will be zero for most characters in normal portrait fonts, but may be non-zero for landscape fonts or for vector-drawing fonts.

**(STRINGWIDTH** *STR FONT FLG RDTBL***)** [Function]

Returns the amount by which a stream's X-position will be incremented if the printname for the Interlisp-D object *STR* is printed in font *FONT*. If *FONT* is an image stream, its font is used. If *FLG* is non-**NIL**, the **PRIN2**-pname of *STR* with respect to the readtable *RDTBL* is used.

**(STRINGREGION** *STR STREAM PRIN2FLG RDTBL***)** [Function]

Returns the region occupied by *STR* if it were printed at the current location in the image stream *STREAM*. This is useful, for example, for determining where text is in a window to allow the user to select it. The arguments *PRIN2FLG* and *RDTBL* are passed to **STRINGWIDTH**.

Note: **STRINGREGION** does not take into account any carriage returns in the string, or carriage returns that may be automatically printed if *STR* is printed to *STREAM*. Therefore, the value returned is meaningless for multi-line strings.

The following functions allow the user to access and change the bitmaps for individual characters in a display font. Note: Character code 256 can be used to access the "dummy" character, used for characters in the font with no bitmap defined.

**(GETCHARBITMAP** *CHARCODE FONT***)** [Function]

Returns a bitmap containing a copy of the image of the character *CHARCODE* in the font *FONT*.

**(PUTCHARBITMAP** *CHARCODE FONT NEWCHARBITMAP NEWCHARDESCENT***)** [Function]

Changes the bitmap image of the character *CHARCODE* in the font *FONT* to the bitmap *NEWCHARBITMAP*. If *NEWCHARDESCENT* is non-**NIL**, the descent of the character is changed to the value of *NEWCHARDESCENT*.

**(EDITCHAR** ***CHARCODE FONT*****)** [Function]

Calls the bitmap editor (**EDITBM**, page 27.4) on the bitmap image of the character *CHARCODE* in the font *FONT*. *CHARCODE* can be a character code (as returned by **CHCON1**) or an atom or string, in which case the first character of *CHARCODE* is used.

## 27.13 Font Files and Font Directories

If **FONTCREATE** is called to create a font that has not been loaded into Interlisp, **FONTCREATE** has to read the font information from a font file that contains the information for that font. For printer devices, the font files have to contain width information for each character in the font. For display fonts, the font files have to contain, in addition, bitmap images for each character in the fonts. The font file names, formats, and searching algorithms are different for each device. There are a set of variables for each device, that determine the directories that are searched for font files. All of these variables must be set before Interlisp can auto-load font files. These variables should be initialized in the site-specific INIT file.

**DISPLAYFONTDIRECTORIES** [Variable]

Value is a list of directories searched to find font bitmap files for display fonts.

**DISPLAYFONTEXTENSIONS** [Variable]

Value is a list of file extensions used when searching **DISPLAYFONTDIRECTORIES** for display fonts. Initially set to **(DISPLAYFONT)**, but when using older font files it may be necessary to add **STRIKE** and **AC** to this list.

**INTERPRESSFONTDIRECTORIES** [Variable]

Value is a list of directories searched to find font widths files for Interpress fonts.

**PRESSFONTWIDTHSFILES** [Variable]

Value is a list of files (not directories) searched to find font widths files for Press fonts. Press font widths are packed into large files (usually named **FONTS.WIDTHS**).

## 27.15 Font Profiles

**PRETTYPRINT** contains a facility for printing different elements (user functions, system functions, clisp words, comments, etc.) in different fonts to emphasize (or deemphasize) their importance, and in general to provide for a more pleasing appearance. Of course, in order to be useful, this facility requires that the user is printing on a device (such as a bitmapped display or a laser printer) which supports multiple fonts.

**PRETTYPRINT** signals font changes by inserting into the file a user-defined escape sequence (the value of the variable **FONTESCAPECHAR**) followed by the character *code* which specifies, by number, which font to use, i.e. ↑**A** for font number 1, etc. Thus, if **FONTESCAPECHAR** were the character ↑F, ↑**F**↑**C** would be output to change to font 3, ↑**F**↑**A** to change to font 1, etc. If **FONTESCAPECHAR** consists of characters which are separator charactors in **FILERDTBL**, then a file with font changes in it can also be loaded back in.

Currently, **PRETTYPRINT** uses the following font classes. The user can specify separate fonts for each of these classes, or use the same font for several different classes.

**LAMBDAFONT** The font for printing the name of the function being prettyprinted, before the actual definition (usually a large font).

**CLISPFONT** If **CLISPFLG** is on, the font for printing any clisp words, i.e. atoms with property **CLISPWORD**.

**COMMENTFONT** The font used for comments.

**USERFONT** The font for the name of any function in the file, or any member of the list **FONTFNS**.

**SYSTEMFONT** The font for any other (defined) function.

**CHANGEFONT** The font for an expression marked by the editor as having been changed.

**PRETTYCOMFONT** The font for the operand of a file package command.

**DEFAULTFONT** The font for everything else.

Note that not all combinations of fonts will be aesthetically pleasing (or even readable!) and the user may have to experiment to find a compatible set.

Although in some implementations **LAMBDAFONT** et al. may be defined as variables, one should not set them directly, but should indicate what font is to be used for each class by calling the function **FONTPROFILE**:

**(FONTPROFILE** ***PROFILE*****)** [Function]

Sets up the font classes as determined by *PROFILE*, a list of elements which defines the correspondence between font classes and specific fonts. Each element of *PROFILE* is a list of the form:

*(FONTCLASS FONT# DISPLAYFONT PRESSFONT INTERPRESSFONT)*

*FONTCLASS* is the font class name and *FONT#* is the font number for that class. For each font class name, the escape sequence will consist of **FONTESCAPECHAR** followed by the character *code* for the font number, e.g. **↑A** for font number 1, etc.

If *FONT#* is **NIL** for any font class, the font class named **DEFAULTFONT** (which must always be specified) is used. Alternatively, if *FONT#* is the name of a previously defined font class, this font class will be equivalenced to the previously defined one.

*DISPLAYFONT*, *PRESSFONT*, and *INTERPRESSFONT* are font specifications (of the form accepted by **FONTCREATE**) for the fonts to use when printing to the display and to Press and Interpress printers respectively.

**FONTPROFILE** [Variable]

This is the *variable* used to store the current font profile, in the form accepted by the *function* **FONTPROFILE**. Note that simply editing this value will not change the fonts used for the various font classes; it is necessary to execute **(FONTPROFILE FONTPROFILE)** to install the value of this variable.

The process of printing with multiple fonts is affected by a large number of variables: **FONTPROFILE**, **FILELINELENGTH**, **PRETTYLCOM**, etc. To facilitate switching back and forth between various sets of values for the font variables, Interlisp supports the idea of named "font configurations" encapsulating the values of all relevant variables.

To create a new font configuration, set all "relevant" variables to the values you want, and then call **FONTNAME** to save them (on the variable **FONTDEFS**) under a given name. To install a particular font configuration, call **FONTSET** giving it your name. To change the values in a saved font configuration, edit the value of the variable **FONTDEFS**.

Note: The list of variables saved by **FONTNAME** is stored in the variable **FONTDEFSVARS**. This can be changed by the user.

**(FONTNAME** *NAME***)** [Function]

Collects the names and values of the variables on **FONTDEFSVARS**, and saves them on **FONTDEFS**.

**(FONTSET** ***NAME*****)** [Function]

Installs font configuration for *NAME*. Also evaluates **(FONTPROFILE FONTPROFILE)** to install the font classes as specified in the new value of the variable **FONTPROFILE**. Generates an error if *NAME* not previously defined.

**FONTDEFSVARS** [Variable]

The list of variables to be packaged by a **FONTNAME**. Initially **FONTCHANGEFLG, FILELINELENGTH, COMMENTLINELENGTH, FIRSTCOL, PRETTYLCOM, LISTFILESTR,** and **FONTPROFILE**.

**FONTDEFS** [Variable]

An association list of font configurations. **FONTDEFS** is a list of elements of form **(*NAME* . *PARAMETER-PAIRS*)**. To save a configuration on a file after performing a **FONTNAME** to define it, the user could either save the entire value of **FONTDEFS**, or use the **ALISTS** file package command (page 17.37) to dump out just the one configuration.

**FONTESCAPECHAR** [Variable]

The character or string used to signal the start of a font escape sequence.

**FONTCHANGEFLG** [Variable]

If **T**, enables fonts when prettyprinting. If **NIL**, disables fonts.

**LISTFILESTR** [Variable]

In Interlisp-10, passed to the operating system by **LISTFILES** (page 17.14). Can be used to specify subcommands to the **LIST** command, e.g. to establish correspondance between font number and font name.

**COMMENTLINELENGTH** [Variable]

Since comments are usually printed in a smaller font, **COMMENTLINELENGTH** is provided to offset the fact that Interlisp does not know about font widths. When **FONTCHANGEFLG = T**, **CAR** of **COMMENTLINELENGTH** is the linelength used to print short comments, i.e. those printed in the right margin, and **CDR** is the linelength used when printing full width comments.

**(CHANGEFONT** ***FONT STREAM*****)** [Function]

Executes the operations on *STREAM* to change to the font *FONT*. For use in **PRETTYPRINTMACROS**.

## 27.16 Image Objects

An Image Object is an object that includes information about an image, such as how to display it, how to print it, and how to manipulate it when it is included in a collection of images (such as a document). More generally, it enables you to include one kind of image, with its own semantics, layout rules, and editing paradigms, inside another kind of image. Image Objects provide a general-purpose interface between image users who want to manipulate arbitrary images, and image producers, who create images for use, say, in documents.

Images are encapsulated inside a uniform barrier—the **IMAGEOBJ** data type. From the outside, you communicate to the image by calling a standard set of functions. For example, calling one function tells you how big the image is; calling another causes the image object to be displayed where you tell it, and so on. Anyone who wants to create images for general use can implement his own brand of **IMAGEOBJ**. **IMAGEOBJ**s have been implemented (in library packages) for bitmaps, menus, annotations, graphs, and sketches.

Image Objects were originally implemented to support inserting images into TEdit text files, but the facility is available for use by any tools that manipulate images. The Image Object interface allows objects to exist in TEdit documents and be edited with their own editor. It also provides a facility in which objects can be shift-selected (or "copy-selected") between TEdit and non-TEdit windows. For example, the Image Objects interface allows you to copy-select graphs from a Grapher window into a TEdit window. The source window (where the object comes from) does not have to know what sort of window the destination window (where the object is inserted) is, and the destination does not have to know where the insertion comes from.

A new data type, **IMAGEOBJ**, contains the data and the procedures necessary to manipulate an object that is to be manipulated in this way. **IMAGEOBJ**s are created with the function **IMAGEOBJCREATE** (below).

Another new data type, **IMAGEFNS**, is a vector of the procedures necessary to define the behavior of a type of **IMAGEOBJ**. Grouping the operations in a separate data type allows multiple instances of the same type of image object to share procedure vectors. The data and procedure fields of an **IMAGEOBJ** have a uniform interface through the function **IMAGEOBJPROP**. **IMAGEFNS** are created with the function **IMAGEFNSCREATE**:

**(IMAGEFNSCREATE** *DISPLAYFN IMAGEBOXFN PUTFN GETFN COPYFN BUTTONEVENTINFN COPYBUTTONEVENTINFN WHENMOVEDFN WHENINSERTEDFN WHENDELETEDFN WHENCOPIEDFN WHENOPERATEDONFN PREPRINTFN* **—)** [Function]

Returns an **IMAGEFNS** object that contains the functions necessary to define the behavior of an **IMAGEOBJ**.

The arguments *DISPLAYFN* through *PREPRINTFN* should all be function names to be stored as the "methods" of the **IMAGEFNS**. The purpose of each **IMAGEFNS** method is described below.

Note: Image objects must be "registered" before they can be read by TEdit or **HREAD** (see page 27.39). **IMAGEFNSCREATE** implicitly registers its *GETFN* argument.

**(IMAGEOBJCREATE** *OBJECTDATUM IMAGEFNS***)** [Function]

Returns an **IMAGEOBJ** that contains the object datum *OBJECTDATUM* and the operations vector *IMAGEFNS*. *OBJECTDATUM* can be arbitrary data.

**(IMAGEOBJPROP** *IMAGEOBJECT PROPERTY NEWVALUE***)** [NoSpread Function]

Accesses and sets the properties of an **IMAGEOBJ**. Returns the current value of the *PROPERTY* property of the image object *IMAGEOBJECT*. If *NEWVALUE* is given, the property is set to it.

**IMAGEOBJPROP** can be used on the system properties **OBJECTDATUM**, **DISPLAYFN**, **IMAGEBOXFN**, **PUTFN**, **GETFN**, **COPYFN**, **BUTTONEVENTINFN**, **COPYBUTTONEVENTINFN**, **WHENOPERATEDONFN**, and **PREPRINTFN**. Additionally, it can be used to save arbitrary properties on an **IMAGEOBJ**.

**(IMAGEFNSP** *X***)** [Function]

Returns *X* if *X* is an **IMAGEFNS** object, **NIL** otherwise.

**(IMAGEOBJP** *X***)** [Function]

Returns *X* if *X* is an **IMAGEOBJ** object, **NIL** otherwise.

## 27.16.1 IMAGEFNS Methods

Note: Many of the **IMAGEFNS** methods below are passed "host stream" arguments. The TEdit text editor passes the "text stream" (an object contain all of the information in the document being edited) as the "host stream" argument. Other editing programs that want to use image objects may want to pass the data structure being edited to the **IMAGEFNS** methods as the "host stream" argument.

**(DISPLAYFN** *IMAGEOBJ IMAGESTREAM IMAGESTREAMTYPE HOSTSTREAM***)** [IMAGEFNS Method]

The **DISPLAYFN** method is called to display the object *IMAGEOBJ* at the current position on *IMAGESTREAM*. The type of *IMAGESTREAM* indicates whether the device is the display or some other image stream.

Note: When the **DISPLAYFN** method is called, the offset and clipping regions for the stream are set so the object's image is at **(0,0)**, and only that image area can be modified.

**(IMAGEBOXFN** *IMAGEOBJ IMAGESTREAM CURRENTX RIGHTMARGIN***)** [IMAGEFNS Method]

The **IMAGEBOXFN** method should return the size of the object as an **IMAGEBOX**, which is a data structure that describes the image laid down when an **IMAGEOBJ** is displayed in terms of width, height, and descender height. An **IMAGEBOX** has four fields: **XSIZE, YSIZE, YDESC,** and **XKERN**. **XSIZE** and **YSIZE** are the width and height of the object image. **YDESC** and **XKERN** give the position of the baseline and the left edge of the image relative to where you want to position it. For characters, the **YDESC** is the descent (height of the descender) and the **XKERN** is the amount of left kerning (note: TEdit doesn't support left kerning).

The **IMAGEBOXFN** looks at the type of the stream to determine the output device if the object's size changes from device to device. (For example, a bit-map object may specify a scale factor that is ignored when the bit map is displayed on the screen.) *CURRENTX* and *RIGHTMARGIN* allow an object to take account of its environment when deciding how big it is. If these fields are not available, they are **NIL**.

Note: TEdit calls the **IMAGEBOXFN** only during line formatting, then caches the **IMAGEBOX** as the **BOUNDBOX** property of the **IMAGEOBJ**. This avoids the need to call the **IMAGEBOXFN** when incomplete position and margin information is available.

**(PUTFN** *IMAGEOBJ FILESTREAM***)** [IMAGEFNS Method]

The **PUTFN** method is called to save the object on a file. It prints a description on *FILESTREAM* that, when read by the corresponding **GETFN** method (see below), regenerates the image object. (TEdit and **HPRINT** take care of writing out the name of the **GETFN**.)

**(GETFN** *FILESTREAM***)** [IMAGEFNS Method]

The **GETFN** method is called when the object is encountered on the file during input. It reads the description that was written by the **PUTFN** method and returns an **IMAGEOBJ**.

**(COPYFN** *IMAGEOBJ SOURCEHOSTSTREAM TARGETHOSTSTREAM***)** [IMAGEFNS Method]

The **COPYFN** method is called during a copy-select operation. It should return a copy of *IMAGEOBJ*. If it returns the litatom **DON'T**, copying is suppressed.

**(BUTTONEVENTINFN** *IMAGEOBJ WINDOWSTREAM SELECTION RELX RELY WINDOW HOSTSTREAM BUTTON***)** [IMAGEFNS Method]

The **BUTTONEVENTINFN** method is called when you press a mouse button inside the object. The **BUTTONEVENTINFN** decides whether or not to handle the button, to track the cursor in parallel with mouse movement, and to invoke selections or edits supported by the object (but see the **COPYBUTTONEVENTINFN** method below). If the **BUTTONEVENTINFN** returns **NIL**, TEdit treats the button press as a selection at its level. Note that when this function is first called, a button is down. The **BUTTONEVENTINFN** should also support the button-down protocol to descend inside of any composite objects with in it. In most cases, the **BUTTONEVENTINFN** relinquishes control (i.e., returns) when the cursor leaves its object's region.

Note: When the **BUTTONEVENTINFN** is called, the window's clipping region and offsets have been changed so that the lower-left corner of the object's image is at **(0,0)**, and only the object's image can be changed. The selection is available for changing to fit your needs; the mouse button went down at **(***RELX***,***RELY***)** within the object's image. You can affect how TEdit treats the selection by returning one of several values. If you return **NIL**, TEdit forgets that you selected an object; if you return the atom **DON'T**, TEdit doesn't permit the selection; if you return the atom **CHANGED**, TEdit updates the screen. Use **CHANGED** to signal TEdit that the object has changed size or will have side effects on other parts of the screen image.

**(COPYBUTTONEVENTINFN** *IMAGEOBJ WINDOWSTREAM***)** [IMAGEFNS Method]

The **COPYBUTTONEVENTINFN** method is called when you button inside an object while holding down a copy key. Many of the comments about **BUTTONEVENTINFN** apply here too. Also, see the discussion below about copying image objects between windows (page 27.41).

**(WHENMOVEDFN** *IMAGEOBJ TARGETWINDOWSTREAM SOURCEHOSTSTREAM TARGETHOSTSTREAM***)** [IMAGEFNS Method]

The **WHENMOVEDFN** method provides hooks by which the object is notified when TEdit performs an operation (MOVEing) on the whole object. It allows objects to have side effects.

**(WHENINSERTEDFN** *IMAGEOBJ TARGETWINDOWSTREAM SOURCEHOSTSTREAM TARGETHOSTSTREAM***)** [IMAGEFNS Method]

The **WHENINSERTEDFN** method provides hooks by which the object is notified when TEdit performs an operation (INSERTing) on the whole object. It allows objects to have side effects.

**(WHENDELETEDFN** *IMAGEOBJ TARGETWINDOWSTREAM***)** [IMAGEFNS Method]

The **WHENDELETEDFN** method provides hooks by which the object is notified when TEdit performs an operation (DELETEing) on the whole object. It allows objects to have side effects.

**(WHENCOPIEDFN** *IMAGEOBJ TARGETWINDOWSTREAM SOURCEHOSTSTREAM TARGETHOSTSTREAM***)** [IMAGEFNS Method]

The **WHENCOPIEDFN** method provides hooks by which the object is notified when TEdit performs an operation (COPYing) on the whole object. The **WHENCOPIEDFN** method is called in addition to (and after) the **COPYFN** method above. It allows objects to have side effects.

**(WHENOPERATEDONFN** *IMAGEOBJ WINDOWSTREAM HOWOPERATEDON SELECTION HOSTSTREAM***)** [IMAGEFNS Method]

The **WHENOPERATEDONFN** method provides a hook for edit operations. *HOWOPERATEDON* should be one of **SELECTED**, **DESELECTED**, **HIGHLIGHTED**, and **UNHILIGHTED**. The **WHENOPERATEDONFN** differs from the **BUTTONEVENTINFN** because it is called when you extend a selection through the object. That is, the object is treated in toto as a TEdit character. **HIGHLIGHTED** refers to the selection being highlighted on the screen, and **UNHIGHLIGHTED** means that the highlighting is being turned off.

**(PREPRINTFN** *IMAGEOBJ***)** [IMAGEFNS Method]

The **PREPRINTFN** method is called to convert the object into something that can be printed for inclusion in documents. It returns an object that the receiving window can print (using either **PRIN1** or **PRIN2**,its choice) to obtain a character representation of the object. If the **PREPRINTFN** method is **NIL**, the **OBJECTDATUM** field of *IMAGEOBJ* itself is used. TEdit uses this function when you indicate that you want to print the characters from an object rather than the object itself (presumably using **PRIN1** case).

## 27.16.2 Registering Image Objects

Each legitimate **GETFN** needs to be known to the system, to prevent various Trojan-horse problems and to allow the automatic loading of the supporting code for infrequently used **IMAGEOBJ**s. To this end, there is a global list, **IMAGEOBJGETFNS**, that contains an entry for each **GETFN**. The existence of the entry marks the **GETFN** as legitimate; the entry itself is a property list, which can hold information about the **GETFN**.

No action needs to be taken for **GETFN**s that are currently in use: the function **IMAGEFNSCREATE** automatically adds its *GETFN* argument to the list. However, packages that support obsolete versions of objects may need to explicitly add the obsolete **GETFN**s. For example, TEdit supports bit-map **IMAGEOBJ**s. Recently, a change was made in the format in which objects are stored; to retain compatibility with the old object format, there are now two **GETFN**s. The current **GETFN** is automatically on the list, courtesy of **IMAGEFNSCREATE**. However, the code file that supports the old bit-map objects contains the clause: **(ADDVARS (IMAGEOBJGETFNS (***OLDGETFNNAME***)))**, which adds the old **GETFN** to **IMAGEOBJGETFNS**.

For a given **GETFN**, the entry on **IMAGEOBJGETFNS** may be a property list of information. Currently the only recognized property is **FILE**.

**FILE** is the name of the file that can be loaded if the **GETFN** isn't defined. This file should define the **GETFN**, along with all the other functions needed to support that kind of **IMAGEOBJ**.

For example, the bit-map **IMAGEOBJ** implemented by TEdit use the **GETFN BMOBJ.GETFN2**. Its entry on **IMAGEOBJGETFNS** is **(BMOBJ.GETFN2 FILE IMAGEOBJ)**, indicating that the support code for bit-map image objects resides on the file **IMAGEOBJ**, and that the **GETFN** for them is **BMOBJ.GETFN2**.

This makes it possible to have entries for **GETFN**s whose supporting code isn't loaded—you might, for instance, have your init file add entries to **IMAGEOBJGETFNS** for the kinds of image objects you commonly use. The system's default reading method will automatically load the code when necessary.

## 27.16.3 Reading and Writing Image Objects on Files

Image Objects can be written out to files using **HPRINT** and read back using **HREAD**. The following functions can also be used:

**(WRITEIMAGEOBJ** *IMAGEOBJ STREAM***)** [Function]

Prints (using **PRIN2**) a call to **READIMAGEOBJ**, then calls the **PUTFN** for *IMAGEOBJ* to write it onto *STREAM*. During input, then, the call to **READIMAGEOBJ** is read and evaluated; it in turn reads back the object's description, using the appropriate **GETFN**.

**(READIMAGEOBJ** *STREAM GETFN NOERROR***)** [Function]

Reads an **IMAGEOBJ** from *STREAM*, starting at the current file position. Uses the function *GETFN* after validating it (and loading support code, if necessary).

If the *GETFN* can't be validated or isn't defined, **READIMAGEOBJ** returns an "encapsulated image object", an **IMAGEOBJ** that safely encapsulates all of the information in the image object. An encapsulated image object displays as a rectangle that says, "**Unknown IMAGEOBJ Type**" and lists the *GETFN*'s name. Selecting an encapsulated image object with the mouse causes another attempt to read the object from the file; this is so you can load any necessary support code and then get to the object.

Warning: You cannot save an encapsulated image object on a file because there isn't enough information to allow copying the description to the new file from the old one.

If *NOERROR* is non-**NIL**, **READIMAGEOBJ** returns **NIL** if it can't successfully read the object.

## 27.16.4 Copying Image Objects Between Windows

Copying between windows is implemented as follows: If a button event occurs in a window when a copy key is down, the window's **COPYBUTTONEVENTFN** window property is called. If this window supports copy-selection, it should track the mouse, indicating the item to be copied. When the button is released, the **COPYBUTTONEVENTFN** should create an image object out of the selected information, and call **COPYINSERT** to insert it in the current TTY window. **COPYINSERT** calls the **COPYINSERTFN** window property of the TTY window to insert this image object. Therefore, both the source and destination windows can determine how they handle copying image objects.

If the **COPYBUTTONEVENTFN** of a window is **NIL**, the **BUTTONEVENTFN** is called instead when a button event occurs in the window when a copy key is down, and copying from that window is not supported. If the **COPYINSERTFN** of the TTY window is **NIL**, **COPYINSERT** will turn the image object into a string (by calling the **PREPRINTFN** method of the image object, see page 27.39) and insert it by calling **BKSYSBUF** (page 30.11).

**COPYBUTTONEVENTFN** [Window Property]

The **COPYBUTTONEVENTFN** of a window is called (if it exists) when a button event occurs in the window and a copy key is down. If no **COPYBUTTONEVENTFN** exists, the **BUTTONEVENTFN** is called.

**COPYINSERTFN** [Window Property]

The **COPYINSERTFN** of the "destination" window is called by **COPYINSERT** to insert something into the destination window. It is called with two arguments: the object to be inserted and the destination window. The object to be inserted can be a character string, an **IMAGEOBJ**, or a list of **IMAGEOBJs** and character strings. As a convention, the **COPYINSERTFN** should call **BKSYSBUF** (page 30.11) if the object to be inserted insert is a character string.

**(COPYINSERT** *IMAGEOBJ***)** [Function]

**COPYINSERT** inserts *IMAGEOBJ* into the window that currently has the TTY. If the current TTY window has a **COPYINSERTFN**, it is called, passing it *IMAGEOBJ* and the window as arguments.

If no **COPYINSERTFN** exists and if *IMAGEOBJ* is an image object, **BKSYSBUF** is called on the result of calling its **PREPRINTFN** on it. If *IMAGEOBJ* is not an image object, it is simply passed to **BKSYSBUF** (page 30.11). In this case, **BKSYSBUF** will call **PRIN2** with a read table taken from the process associated with the TTY window. A window that wishes to use **PRIN1** or a different read table must provide its own **COPYINSERTFN** to do this.

## 27.17 Implementation of Image Streams

Interlisp does all image creation through a set of functions and data structures for device-independent graphics, known popularly as DIG. DIG is implemented through the use of a special type of stream, known as an image stream.

An image stream, by convention, is any stream that has its **IMAGEOPS** field (described in detail below) set to a vector of meaningful graphical operations. Using image streams, you can write programs that draw and print on an output stream without regard to the underlying device, be it a window, a disk, or a printer.

To define a new image stream type, it is necessary to put information on the variable **IMAGESTREAMTYPES**:

**IMAGESTREAMTYPES** [Variable]

This variable describes how to create a stream for a given image stream type. The value of **IMAGESTREAMTYPES** is an association list, indexed by the image stream type (e.g., **DISPLAY**, **INTERPRESS**, etc.). The format of a single association list item is:

**(***IMAGETYPE*
  **(OPENSTREAM** *OPENSTREAMFN***)**

**(FONTCREATE** *FONTCREATEFN***)**
**(FONTSAVAILABLE** *FONTSAVAILABLEFN***))**

*OPENSTREAMFN*, *FONTCREATEFN*, and *FONTSAVAILABLEFN* are "image stream methods," device-dependent functions used to implement generic image stream operations. For Interpress image streams, the association list entry is:

**(INTERPRESS**
**(OPENSTREAM OPENIPSTREAM)**
**(FONTCREATE \CREATEINTERPRESSFONT)**
**(FONTSAVAILABLE \SEARCHINTERPRESSFONTS))**

**(OPENSTREAMFN** *FILE OPTIONS***)** [Image Stream Method]

*FILE* is the file name as it was passed to **OPENIMAGESTREAM**, and *OPTIONS* is the *OPTIONS* property list passed to **OPENIMAGESTREAM**. The result must be a stream of the appropriate image type.

**(FONTCREATEFN** *FAMILY SIZE FACE ROTATION DEVICE***)** [Image Stream Method]

*FAMILY* is the family name for the font, e.g., **MODERN**. *SIZE* is the body size of the font, in printer's points. *FACE* is a three-element list describing the weight, slope, and expansion of the face desired, e.g., **(MEDIUM ITALIC EXPANDED)**. *ROTATION* is how much the font is to be rotated from the normal orientation, in minutes of arc. For example, to print a landscape page, fonts have the rotation 5400 (90 degrees). The function's result must be a **FONTDESCRIPTOR** with the fields filled in appropriately.

**(FONTSAVAILABLEFN** *FAMILY SIZE FACE ROTATION DEVICE***)** [Image Stream Method]

This function returns a list of all fonts agreeing with the *FAMILY*, *SIZE*, *FACE*, and *ROTATION* arguments; any of them may be wild-carded (i.e., equal to *, which means any value is acceptable). Each element of the list should be a quintuple of the form **(***FAMILY SIZE FACE ROTATION DEVICE***)**.

Where the function looks is an implementation decision: the *FONTSAVAILABLEFN* for the display device looks at **DISPLAYFONTDIRECTORIES**, the Interpress code looks on **INTERPRESSFONTDIRECTORIES**, and implementors of new devices should feel free to introduce new search path variables.

As indicated above, image streams use a field that no other stream uses: **IMAGEOPS**. **IMAGEOPS** is an instance of the **IMAGEOPS** data type and contains a vector of the stream's graphical methods. The methods contained in the **IMAGEOPS** object can make arbitrary use of the stream's **IMAGEDATA** field, which is provided for their use, and may contain any data needed.

The **IMAGEOPS** data type has the following fields:

**IMAGETYPE** [IMAGEOPS Field]

Value is the name of an image type. Monochrome display streams have an **IMAGETYPE** of **DISPLAY**; color display streams are identified as **(COLOR DISPLAY)**. The **IMAGETYPE** field is informational and can be set to anything you choose.

**IMFONTCREATE** [IMAGEOPS Field]

Value is the device name to pass to **FONTCREATE** when fonts are created for the stream.

The remaining fields are all image stream methods, whose value should be a device-dependent function that implements the generic operation. Most methods are called by a similarly-named function, e.g. the function **DRAWLINE** calls the **IMDRAWLINE** method. All coordinates that refer to points in a display device's space are measured in the device's units. (The **IMSCALE** method provides access to a device's scale.) For arguments that have defaults (such as the *BRUSH* argument of **DRAWCURVE**), the default is substituted for the **NIL** argument before it is passed to the image stream method. Therefore, image stream methods do not have to handle defaults.

**(IMCLOSEFN** *STREAM***)** [Image Stream Method]

Called before a stream is closed with **CLOSEF**. This method should flush buffers, write header or trailer information, etc.

**(IMDRAWLINE** *STREAM* $X_1$ $Y_1$ $X_2$ $Y_2$ *WIDTH OPERATION COLOR DASHING***)** [Image Stream Method]

Draws a line of width *WIDTH* from ($X_1$, $Y_1$) to ($X_2$, $Y_2$). See **DRAWLINE**, page 27.17.

**(IMDRAWCURVE** *STREAM KNOTS CLOSED BRUSH DASHING***)** [Image Stream Method]

Draws a curve through *KNOTS*. See **DRAWCURVE**, page 27.19.

**(IMDRAWCIRCLE** *STREAM CENTERX CENTERY RADIUS BRUSH DASHING***)** [Image Stream Method]

Draws a circle of radius *RADIUS* around (*CENTERX*, *CENTERY*). See **DRAWCIRCLE**, page 27.19.

**(IMDRAWELLIPSE** *STREAM CENTERX CENTERY SEMIMINORRADIUS SEMIMAJORRADIUS ORIENTATION BRUSH DASHING***)** [Image Stream Method]

Draws an ellipse around **(***CENTERX, CENTERY***)**. See **DRAWELLIPSE**, page 27.19.

**(IMFILLPOLYGON** *STREAM POINTS TEXTURE***)** [Image Stream Method]

Fills in the polygon outlined by *POINTS* on the image stream *STREAM*, using the texture *TEXTURE*. See **FILLPOLYGON**, page 27.20.

**(IMFILLCIRCLE** *STREAM CENTERX CENTERY RADIUS TEXTURE***)** [Image Stream Method]

Draws a circle filled with texture *TEXTURE* around **(***CENTERX, CENTERY***)**. See **FILLCIRCLE**, page 27.21.

**(IMBLTSHADE** *TEXTURE STREAM DESTINATIONLEFT DESTINATIONBOTTOM WIDTH HEIGHT OPERATION CLIPPINGREGION***)** [Image Stream Method]

The texture-source case of **BITBLT** (page 27.14). *DESTINATIONLEFT, DESTINATIONBOTTOM, WIDTH, HEIGHT*, and *CLIPPINGREGION* are measured in *STREAM*'s units. This method is invoked by the functions **BITBLT** and **BLTSHADE** (page 27.16).

**(IMBITBLT** *SOURCEBITMAP SOURCELEFT SOURCEBOTTOM STREAM DESTINATIONLEFT DESTINATIONBOTTOM WIDTH HEIGHT SOURCETYPE OPERATION TEXTURE CLIPPINGREGION CLIPPEDSOURCELEFT CLIPPEDSOURCEBOTTOM SCALE***)** [Image Stream Method]

Contains the bit-map-source cases of **BITBLT** (page 27.14). *SOURCELEFT, SOURCEBOTTOM, CLIPPEDSOURCELEFT, CLIPPEDSOURCEBOTTOM, WIDTH*, and *HEIGHT* are measured in pixels; *DESTINATIONLEFT, DESTINATIONBOTTOM*, and *CLIPPINGREGION* are in the units of the destination stream.

**(IMSCALEDBITBLT** *SOURCEBITMAP SOURCELEFT SOURCEBOTTOM STREAM DESTINATIONLEFT DESTINATIONBOTTOM WIDTH HEIGHT SOURCETYPE OPERATION TEXTURE CLIPPINGREGION CLIPPEDSOURCELEFT CLIPPEDSOURCEBOTTOM SCALE***)** [Image Stream Method]

A scaled version of **IMBITBLT**. Each pixel in *SOURCEBITMAP* is replicated *SCALE* times in the X and Y directions; currently, *SCALE* must be an integer.

**(IMMOVETO** *STREAM X Y***)** [Image Stream Method]

Moves to **(***X,Y***)**. This method is invoked by the function **MOVETO** (page 27.13). If **IMMOVETO** is not supplied, a default method composed of calls to the **IMXPOSITION** and **IMYPOSITION** methods is used.

**(IMSTRINGWIDTH** *STREAM STR RDTBL***)** [Image Stream Method]

Returns the width of string *STR* in *STREAM*'s units, using *STREAM*'s current font. This is envoked when **STRINGWIDTH** (page 27.30) is passed a stream as its *FONT* argument. If **IMSTRINGWIDTH** is not supplied, it defaults to calling **STRINGWIDTH** on the default font of *STREAM*.

**(IMCHARWIDTH** *STREAM CHARCODE***)** [Image Stream Method]

Returns the width of character *CHARCODE* in *STREAM*'s units, using *STREAM*'s current font. This is invoked when **CHARWIDTH** (page 27.30) is passed a stream as its *FONT* argument. If **IMCHARWIDTH** is not supplied, it defaults to calling **CHARWIDTH** on the default font of *STREAM*.

**(IMCHARWIDTHY** *STREAM CHARCODE***)** [Image Stream Method]

Returns the Y componant of the width of character *CHARCODE* in *STREAM*'s units, using *STREAM*'s current font. This is envoked when **CHARWIDTHY** (page 27.30) is passed a stream as its *FONT* argument. If **IMCHARWIDTHY** is not supplied, it defaults to calling **CHARWIDTHY** on the default font of *STREAM*.

**(IMBITMAPSIZE** *STREAM BITMAP DIMENSION***)** [Image Stream Method]

Returns the size that *BITMAP* will be when **BITBLT**ed to *STREAM*, in *STREAM*'s units. *DIMENSION* can be one of **WIDTH**, **HEIGHT**, or **NIL**, in which case the dotted pair **(***WIDTH* . *HEIGHT***)** will be returned.

This is envoked by **BITMAPIMAGESIZE** (page 27.16). If **IMBITMAPSIZE** is not supplied, it defaults to a method that multiplies the bitmap height and width by the scale of *STREAM*.

**(IMNEWPAGE** *STREAM***)** [Image Stream Method]

Causes a new page to be started. The X position is set to the left margin, and the Y position is set to the top margin plus the linefeed. If not supplied, defaults to **(\OUTCHAR** *STREAM* **(CHARCODE ↑L))**. Envoked by **DSPNEWPAGE** (page 27.21).

**(IMTERPRI** *STREAM***)** [Image Stream Method]

Causes a new line to be started. The X position is set to the left margin, and the Y position is set to the current Y position plus the linefeed. If not supplied, defaults to **(\OUTCHAR** *STREAM* **(CHARCODE EOL))**. Envoked by **TERPRI** (page 25.9).

**(IMRESET** *STREAM***)** [Image Stream Method]

Resets the X and Y position of *STREAM*. The X coordinate is set to its left margin; the Y coordinate is set to the top of the clipping region minus the font ascent. Envoked by **DSPRESET**, page 27.21.

The following methods all have corresponding **DSP***xx* functions (e.g., **IMYPOSITION** corresponds to **DSPYPOSITION**) that invoke them. They also have the property of returning their previous value; when called with **NIL** they return the old value without changing it.

**(IMCLIPPINGREGION** *STREAM REGION***)** [Image Stream Method]

Sets a new clipping region on *STREAM*.

**(IMXPOSITION** *STREAM XPOSITION***)** [Image Stream Method]

Sets the X-position on *STREAM*.

**(IMYPOSITION** *STREAM YPOSITION***)** [Image Stream Method]

Sets a new Y-position on *STREAM*.

**(IMFONT** *STREAM FONT***)** [Image Stream Method]

Sets *STREAM*'s font to be *FONT*.

**(IMLEFTMARGIN** *STREAM LEFTMARGIN***)** [Image Stream Method]

Sets *STREAM*'s left margin to be *LEFTMARGIN*. The left margin is defined as the X-position set after the new line.

**(IMRIGHTMARGIN** *STREAM RIGHTMARGIN***)** [Image Stream Method]

Sets *STREAM*'s right margin to be *RIGHTMARGIN*. The right margin is defined as the maximum X-position at which characters are printed; printing beyond it causes a new line.

**(IMTOPMARGIN** *STREAM YPOSITION***)** [Image Stream Method]

Sets *STREAM*'s top margin (the Y-position of the tops of characters that is set after a new page) to be *YPOSITION*.

**(IMBOTTOMMARGIN** *STREAM YPOSITION***)** [Image Stream Method]

Sets *STREAM*'s bottom margin (the Y-position beyond which any printing causes a new page) to be *YPOSITION*.

**(IMLINEFEED** *STREAM DELTA***)** [Image Stream Method]

Sets *STREAM*'s line feed distance (distance to move vertically after a new line) to be *DELTA*.

**(IMSCALE** *STREAM SCALE***)** [Image Stream Method]

Returns the number of device points per screen point (a screen point being ~1/72 inch). *SCALE* is ignored.

**(IMSPACEFACTOR** *STREAM FACTOR***)** [Image Stream Method]

Sets the amount by which to multiply the natural width of all following space characters on *STREAM*; this can be used for the justification of text. The default value is 1. For example, if the natural width of a space in *STREAM*'s current font is 12 units, and the space factor is set to two, spaces appear 24 units wide. The values returned by **STRINGWIDTH** and **CHARWIDTH** are also affected.

**(IMOPERATION** *STREAM OPERATION***)** [Image Stream Method]

Sets the default **BITBLT** *OPERATION* argument (see page 27.15).

**(IMBACKCOLOR** *STREAM COLOR***)** [Image Stream Method]

Sets the background color of *STREAM*.

**(IMCOLOR** *STREAM COLOR***)** [Image Stream Method]

Sets the default color of *STREAM*.

In addition to the **IMAGEOPS** methods described above, there are two other important methods, which are contained in the stream itself. These fields can be installed using a form like **(replace (STREAM OUTCHARFN) of STREAM with (FUNCTION MYOUTCHARFN))**. Note: You need to have loaded the Interlisp-D system declarations to manipulate the fields of **STREAM**s. The declarations can be loaded by loading the Lisp Library package **SYSEDIT**.

**(STRMBOUTFN** *STREAM CHARCODE***)** [Stream Method]

The function called by **BOUT**.

**(OUTCHARFN** *STREAM CHARCODE***)** [Stream Method]

The function that is called to output a single byte. This is like **STRMBOUTFN**, except for being one level higher: it is intended for text output. Hence, this function should convert **(CHARCODE EOL)** into the stream's actual end-of-line sequence and should adjust the stream's **CHARPOSITION** appropriately before invoking the stream's **STRMBOUTFN** (by calling **BOUT**) to actually put the character. Defaults to **\FILEOUTCHARFN**, which is probably incorrect for an image stream.

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# 28. WINDOWS AND MENUS

Windows provide a means by which different programs can share a single display harmoniously. Rather than having every program directly manipulating the screen bitmap, all display input/output operations are directed towards windows, which appear as rectangular regions of the screen, with borders and titles. The Interlisp-D window system provides both interactive and programmatic constructs for creating, moving, reshaping, overlapping, and destroying windows in such a way that a program can use a window in a relatively transparent fashion (see page 28.12). This allows existing Interlisp programs to be used without change, while providing a base for experimentation with more complex windows in new applications.

Menus are a special type of window provided by the window system, used for displaying a set of items to the user, and having the user select one using the mouse and cursor. The window system uses menus to provide the interactive interface for manipulating windows. The menu facility also allows users to create and use menus in interactive programs (see page 28.37).

Sometimes, a program needs to use a number of windows, displaying related information. The attached window facility (page 28.45) makes it easy to manipulate a group of windows as a single unit, moving and reshaping them together.

This chapter documents the Interlisp-D window system. First, it describes the default windows and menus supplied by the window system. Then, the programmatic facilities for creating windows. Next, the functions for using menus. Finally, the attached window facility.

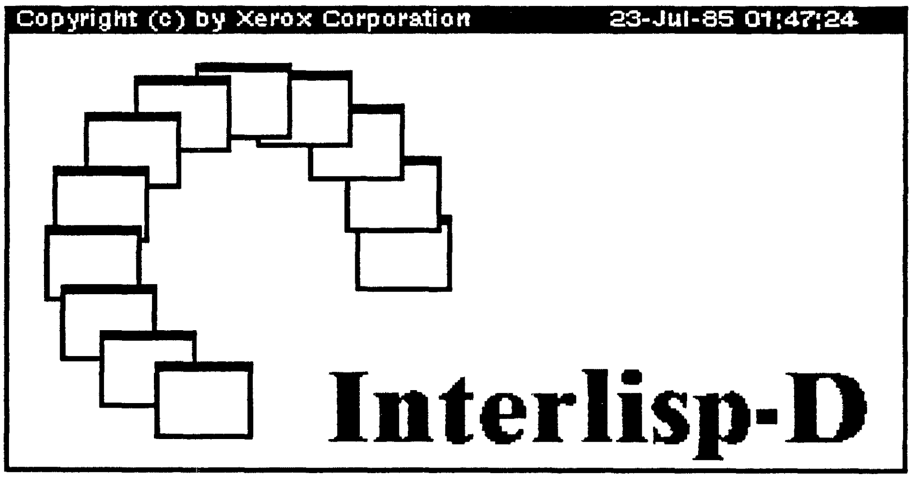
Warning: The window system assumes that all programs follow certain conventions concerning control of the screen. All user programs should use perform display operations using windows and menus. In particular, user programs should not perform operate directly on the screen bitmap; otherwise the window system will not work correctly. For specialized applications that require taking complete control of the display, the window system can be turned off (and back on again) with the following function:

**(WINDOWWORLD *FLAG*)** [NoSpread Function]

The window system is turned on if *FLAG* is **T** and off if *FLAG* is **NIL**. **WINDOWWORLD** returns the previous state of the window system (**T** or **NIL**). If **WINDOWWORLD** is given no arguments, it simply returns the current state without affecting the window system.

## 28.1 Using The Window System

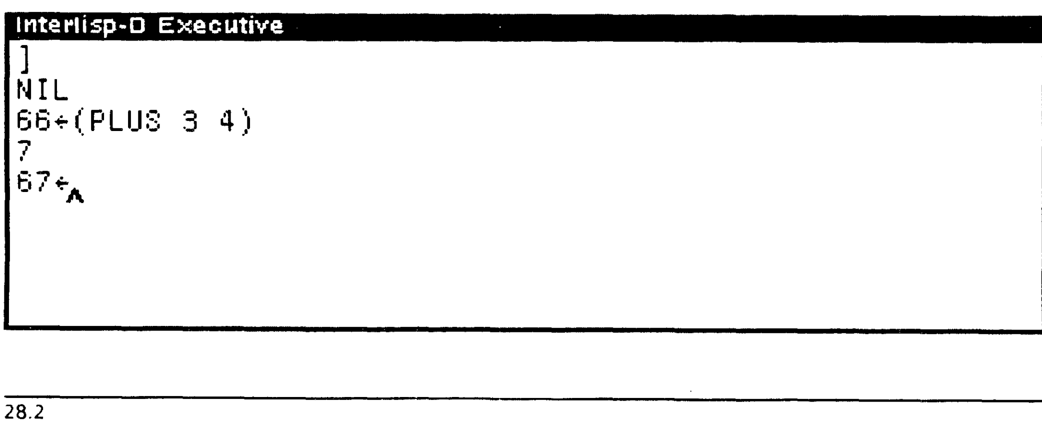
When Interlisp-D is initially started, the display screen lights up, showing a number of windows, including the following:



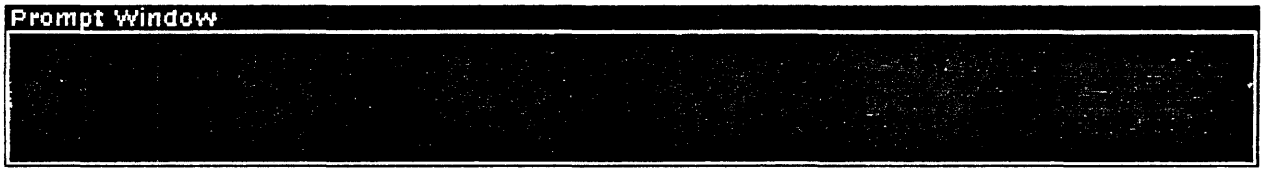

This window is the "logo window," used to identify the system. The logo window is bound to the variable **LOGOW** until it is closed. The user can create other windows like this by calling the following function:

(**LOGOW** *STRING WHERE TITLE ANGLEDELTA*) [Function]

Creates a window formatted like the "logo window." *STRING* is the string to be printed in big type in the window; if **NIL**, "Interlisp-D" is used. *WHERE* is the position of the lower-left corner of the window; if **NIL**, the user is asked to specify a position. *TITLE* is the window title to use; if **NIL**, it defaults to the Xerox copyright notice and date. *ANGLEDELTA* specifies the angle (in degrees) between the boxes in the picture; if **NIL**, it defaults to 23 degrees.



This window is the "executive window," used for typing expressions and commands to the Interlisp-D executive, and for the executive to print any results (see page 13.1). For example, in the above picture, the user typed in **(PLUS 3 4)**, the executive evaluated it, and printed out the result, **7**. The upward-pointing arrow (**▲**) is the flashing caret, which indicates where the next keyboard typein will be printed (see page 28.30).




This window is the "prompt window," used for printing various system prompt messages. It is available to user programs through the following functions:

**PROMPTWINDOW** [Variable]

Global variable containing the prompt window.

**(PROMPTPRINT** $EXP_1$ ... $EXP_N$**)** [NoSpread Function]

Clears the prompt window, and prints $EXP_1$ through $EXP_N$ in the prompt window.

**(CLRPROMPT)** [Function]

Clears the prompt window.

The Interlisp-D window system allows the user to interactively manipulate the windows on the screen, moving them around, changing their shape, etc. by selecting various operations from a menu.

For most windows, depressing the **RIGHT** mouse key when the cursor is inside a window during I/O wait will cause the window to come to the top and a menu of window operations to appear. If a command is selected from this menu (by releasing the right mouse key while the cursor is over a command), the selected operation will be applied to the window in which the menu was brought up. It is possible for an applications program to redefine the action of the **RIGHT** mouse key. In these cases, there is a convention that the default command menu may be brought up by depressing the **RIGHT** key when the cursor is in the header or border of a window (page 28.28). The operations are:

**Close** [Window Menu Command]

Closes the window, i.e, removes it from the screen. (See **CLOSEW**, page 28.15.)

**Snap** [Window Menu Command]

Prompts for a region on the screen and makes a new window whose bits are a snapshot of the bits currently in that region. Useful for saving some particularly choice image before the window image changes.

**Paint** [Window Menu Command]

Switches to a mode in which the cursor can be used like a paint brush to draw in a window. This is useful for making notes on a window. While the **LEFT** key is down, bits are added. While the **MIDDLE** key is down, they are erased. The **RIGHT** button pops up a command menu that allows changing of the brush shape, size and shade, changing the mode of combining the brush with the existing bits, or stopping paint mode.

**Clear** [Window Menu Command]

Clears the window and repositions it to the left margin of the first line of text (below the upper left corner of the window by the amount of the font ascent).

**Bury** [Window Menu Command]

Puts the window on the bottom of the occlusion stack, thereby exposing any windows that it was hiding.

**Redisplay** [Window Menu Command]

Redisplays the window. (See **REDISPLAYW**, page 28.16.)

**Hardcopy** [Window Menu Command]

Prints the contents of the window to the printer. If the window has a window property **HARDCOPYFN** (page 28.34), it is called with two arguments, the window and an image stream to print to, and the **HARDCOPYFN** must do the printing. In this way, special windows can be set up that know how to print their contents in a particular way. If the window does not have a **HARDCOPYFN**, the bitmap image of the window (including the border and title) are printed on the file or printer.

To save the image in a Press or Interpress-format file, or to send it to a non-default printer, use the submenu of the **Hardcopy** command, indicated by a gray triangle on the right edge of the **Hardcopy** menu item. If the mouse is moved off of the right of the menu item, another pop-up menu will apear giving the choices "To a file" or "To a printer." If "To a file" is selected, the user is prompted to supply a file name, and the format of the file (Press, Interpress, etc.), and the specified region will be stored in the file.

If "To a printer" is selected, the user is prompted to select a printer from the list of known printers, or to type the name of another printer. If the printer selected is not the first printer on **DEFAULTPRINTINGHOST** (page 29.4), the user will be asked whether to move or add the printer to the beginning of this list, so that future printing will go to the new printer.

**Move** [Window Menu Command]

Moves the window to a location specified by depressing and then releasing the **LEFT** key. During this time a ghost frame will indicate where the window will reappear when the key is released. (See **GETBOXPOSITION**, page 28.9.)

**Shape** [Window Menu Command]

Allows the user to specify a new region for the existing window contents. If the **LEFT** key is used to specify the new region, the reshaped window can be placed anywhere. If the **MIDDLE** key is used, the cursor will start out tugging at the nearest corner of the existing window, which is useful for making small adjustments in a window that is already positioned correctly. This is done by calling the function **SHAPEW** (page 28.16).

Occasionally, a user will have a number of large windows on the screen, making it difficult to access those windows being used. To help with the problem of screen space management, the Interlisp-D window system allows the creation of "icons." An icon is a small rectangle (containing text or a bitmap) which is a "shrunken-down" form of a particular window. Using the **Shrink** and **Expand** commands, the user can shrink windows not currently being used into icons, and quickly restore the original windows at any time.

**Shrink** [Window Menu Command]

Removes the window from the screen and brings up its icon. (See **SHRINKW**, page 28.21.) The window can be restored by selecting **Expand** from the window command menu of the icon.

If the **RIGHT** button is pressed while the cursor is in an icon, the window command menu will contain a slightly different set of commands. The **Redisplay** and **Clear** commands are removed, and the **Shrink** command is replaced with the **Expand** command:

**Expand** [Window Menu Command]

Restores the window associated with this icon and removes the icon. (See **EXPANDW**, page 28.22.)

If the **RIGHT** button is pressed while the cursor is not in any window, a "background menu" appears with the following operations:

**Idle** [Background Menu Command]

Enters "idle mode" (see page 12.4), which blacks out the display screen to save the phosphor. Idle mode can be exited by pressing any key on the keyboard or mouse. This menu command has subitems that allow the user to interactively set idle options to erase the password cache (for security), to request a password before exiting idle mode, to change the timeout before idle mode is entered automatically, etc.

**SaveVM** [Background Menu Command]

Calls the function **SAVEVM** (page 12.7), which writes out all of the dirty pages of the virtual memory. After a **SAVEVM**, and until the pagefault handler is next forced to write out a dirty page, your virtual memory image will be continuable (as of the **SAVEVM)** should you experience a system crash or other disaster.

**Snap** [Background Menu Command]

The same as the window menu command **Snap** described above.

**Hardcopy** [Background Menu Command]

Prompts for a region on the screen, and sends the bitmap image to the printer by calling **HARDCOPYW** (page 29.3). Note that the region can cross window boundaries.

Like the **Hardcopy** window menu command (above), the user can print to a file or specify a printer by using a submenu.

**PSW** [Background Menu Command]

Prompts the user for a position on the screen, and creates a "process status window" that allows the user to examine and manipulate all of the existing processes (see page 23.16).

Various system utilities (TEdit, DEdit, TTYIN) allow information to be "copy-inserted" at the current cursor position by selecting it with the "copy" key held down (Normally the shift keys are the "copy" key; this action can be changed in the key action table.) To "copy-insert" the bitmap of a snap into a Tedit document. If the right mouse button is pressed in the background with the copy key held down, a menu with the single item "**SNAP**" appears. If this item is selected, the user is prompted to select a region, and a bitmap containing the bits in that region of the screen is inserted into the current tty process, if that process is able to accept image objects.

Some built-in facilities and Lispusers packages add commands to the background menu, to provide an easy way of calling the different facilities. The user can determine what these new commands do by holding the **RIGHT** button down for a few seconds over the item in question; an explanatory message will be printed in the prompt window.

## 28.2 Changing Window Command Menus

The following functions provide a functional interface to the interactive window operations so that user programs can call them directly.

**(DOWINDOWCOM** *WINDOW***)** [Function]

If *WINDOW* is a **WINDOW** that has a **DOWINDOWCOMFN** window property, it **APPLY**s that property to **WINDOW**. Shrunken windows have a **DOWINDOWCOMFN** property that presents a window command menu that contains "expand" instead of "shrink".

If *WINDOW* is a **WINDOW** that doesn't have a **DOWINDOWCOMFN** window property, it brings up the window command menu. The initial items in these menus are described above. If the user selects one of the items from the provided menu, that item is **APPLY**ed to *WINDOW*.

If *WINDOW* is **NIL, DOBACKGROUNDCOM** (below) is called.

If *WINDOW* is not a **WINDOW** or **NIL, DOWINDOWCOM** simply returns without doing anything.

**(DOBACKGROUNDCOM)** [Function]

Brings up the background menu. The initial items in this menu are described above. If the user selects one of the items from the menu, that item is **EVAL**ed.

The window command menu for unshrunken windows is cached in the variable **WindowMenu**. To change the entries in this menu, the user should change the change the menu "command lists" in the variable **WindowMenuCommands**, and set the appropriate menu variable to a non-**MENU**, so the menu will be recreated. This provides a way of adding commands to the menu, of changing its font or of restoring the menu if it gets clobbered. The window command menus for icons and the background have similar pairs of variables, documented below. The "command lists" are in the format of the **ITEMS** field of a menu (see page 28.39), except as specified below.

Note: Command menus are recreated using the current value of **MENUFONT**.

**WindowMenu** [Variable]

**WindowMenuCommands** [Variable]

The menu that is brought up in response to a right button in an unshrunken window is stored on the variable **WindowMenu**. If **WindowMenu** is set to a non-**MENU**, the menu will be recreated from the list of commands **WindowMenuCommands**. The **CADR** of each command added to **WindowMenuCommands** should be a function name that will be **APPLY**ed to the window.

**IconWindowMenu** [Variable]

**IconWindowMenuCommands** [Variable]

The menu that is brought up in response to a right button in a shrunken window is stored on the variable **IconWindowMenu**. If it is **NIL**, it is recreated from the list of commands **IconWindowMenuCommands**. The **CADR** of each command added a function name that will be **APPLY**ed to the window.

**BackgroundMenu** [Variable]

**BackgroundMenuCommands** [Variable]

The menu that is brought up in response to a right button in the background is stored on the variable **BackgroundMenu**. If it is **NIL**, it is recreated from the list of commands **BackgroundMenuCommands**. The **CADR** of each command added to **BackgroundMenuCommands** should be a form that will be **EVAL**ed.

**BackgroundCopyMenu** [Variable]

**BackgroundCopyMenuCommands** [Variable]

The menu that is brought up in response to a right button in the background when the copy key is down is stored on the variable **BackgroundCopyMenu**. If it is **NIL**, it is recreated from the list of commands **BackgroundCopyMenuCommands**. The **CADR** of each command added to **BackgroundCopyMenuCommands** should be a form that will be **EVAL**ed.

## 28.3 Interactive Display Functions

The following functions can be used by programs to allow the user to interactively specify positions or regions on the display screen.

**(GETPOSITION** *WINDOW CURSOR***)** [Function]

Returns a **POSITION** that is specified by the user. **GETPOSITION** waits for the user to press and release the left button of the mouse and returns the cursor position at the time of release. If *WINDOW* is a **WINDOW**, the position will be in the coordinate system of *WINDOW*'s display stream. If *WINDOW* is **NIL**, the position will be in screen coordinates. If *CURSOR* is a **CURSOR** (page 30.14), the cursor will be changed to it while **GETPOSITION** is running. If *CURSOR* is **NIL**, the value of the system variable **CROSSHAIRS** will be used as the cursor: ⊕.

**(GETBOXPOSITION** *BOXWIDTH BOXHEIGHT ORGX ORGY WINDOW PROMPTMSG***)** [Function]

Allows the user to position a "ghost" region of size *BOXWIDTH* by *BOXHEIGHT* on the screen, and returns the **POSITION** of the lower left corner of the region. If *PROMPTMSG* is non-**NIL**, **GETBOXPOSITION** first prints it in the **PROMPTWINDOW**. **GETBOXPOSITION** then changes the cursor to a box (using the global variable **BOXCURSOR**: ). If *ORGX* and *ORGY* are numbers, they are taken to be the original position of the region, and the cursor is moved to the nearest corner of that region. A ghost region is locked to the cursor so that if the cursor is moved, the ghost region moves with it. If *ORGX* and *ORGY* are numbers, the corner of the region formed by (*ORGX ORGY BOXWIDTH BOXHEIGHT*) that is nearest the cursor position is locked, otherwise the lower left corner is locked. The user can change to another corner by holding down the right button. With the right button down, the cursor can be moved across the screen without effect on the ghost region frame. When the right button is released, the mouse will snap to the nearest corner, which will then become locked to the cursor. (The held corner can be changed after the left or middle button is down by holding both the original button and the right button down while the cursor is moved to the desired new corner, then letting up just the right button.) When the left or middle button is pressed and released, the lower left corner of the region at the time of release is returned. If *WINDOW* is a **WINDOW**, the returned position will be in *WINDOW*'s coordinate system; otherwise it will be in screen coordinates.

Example:

**(GETBOXPOSITION 100 200 NIL NIL NIL**
**"Specify the position of the command area.")**

prompts the user for a 100 wide by 200 high region and returns its lower left corner in screen coordinates.

**(GETREGION** *MINWIDTH MINHEIGHT OLDREGION NEWREGIONFN NEWREGIONFNARG INITCORNERS***)** [Function]

Lets the user specify a new region and returns that region in screen coordinates. **GETREGION** prompts for a region by displaying a four-pronged box next to the cursor arrow at one corner of a "ghost" region: . If the user presses the left button, the corner of a "ghost" region opposite the cursor is locked where it is. Once one corner has been fixed, the ghost region expands as the cursor moves.

To specify a region: (1) Move the ghost box so that the corner opposite the cursor is at one corner of the intended region. (2) Press the left button. (3) Move the cursor to the position of the opposite corner of the intended region while holding down the left button. (4) Release the left button.

Before one corner has been fixed, one can switch the cursor to another corner of the ghost region by holding down the right button. With the right button down, the cursor changes to a "forceps" () and the cursor can be moved across the screen without effect on the ghost region frame. When the right button is released, the cursor will snap to the nearest corner of the ghost region.

After one corner has been fixed, one can still switch to another corner. To change to another corner, continue to hold down the left button and hold down the right button also. With both buttons down, the cursor can be moved across the screen without effect on the ghost region frame. When the right button is released, the cursor will snap to the nearest corner, which will become the moving corner. In this way, the region may be moved all over the screen, before its size and position is finalized.

The size of the initial ghost region is controlled by the *MINWIDTH*, *MINHEIGHT*, *OLDREGION*, and *INITCORNERS* arguments.

If *INITCORNERS* is non-**NIL**, it should be a list specifying the initial corners of a ghost region of the form **(***BASEX BASEY OPPX OPPY***)**, where (*BASEX*, *BASEY*) describes the anchored corner of the box, and (*OPPX*, *OPPY*) describes the trackable corner (in screen coordinates). The cursor is moved to (*OPPX*, *OPPY*).

If *INITCORNERS* is **NIL**, the ghost region will be *MINWIDTH* wide and *MINHEIGHT* high. If *MINWIDTH* or *MINHEIGHT* is **NIL**, 0 is used. Thus, for a call to **GETREGION** with no arguments specified, there will be no initial ghost region. The cursor will be in the lower right corner of the region, if there is one.

If *OLDREGION* is a region and the user presses the middle button, the corner of *OLDREGION* farthest from the cursor position is fixed and the corner nearest the cursor is locked to the cursor.

*MINWIDTH* and *MINHEIGHT*, if given, are the smallest **WIDTH** and **HEIGHT** that the returned region will have. The ghost image will not get any smaller than *MINWIDTH* by *MINHEIGHT*.

If *NEWREGIONFN* is non-**NIL**, it will be called to determine values for the positions of the corners. This provides a way of "filtering" prospective regions; for instance, by restricting the region to lie on an arbitrary grid. When the user is specifying a region, the region is determined by two of its corners, one that is fixed and one that is tracking the cursor. Each time the cursor moves or a mouse button is pressed, *NEWREGIONFN* is called with three arguments: *FIXEDPOINT*, the position of the fixed corner of the prospective region; *MOVINGPOINT*, the position of the opposite corner of the prospective region; and *NEWREGIONFNARG*. *NEWREGIONFNARG* allows the caller of **GETREGION** to pass information to the *NEWREGIONFN*.

The first time a button is pressed and when the user changes the moving corner via right buttoning, *MOVINGPOINT* is **NIL** and *FIXEDPOINT* is the position the user selected for the fixed corner of the new region. In this case, the position returned by *NEWREGIONFN* will be used for the fixed corner instead of the one proposed by the user. For all other calls, *FIXEDPOINT* is the position of the fixed corner (as returned by the previous call) and *MOVINGPOINT* is the new position the user selected for the opposite corner. In these cases, the value of *NEWREGIONFN* is used for the opposite corner instead of the one proposed by the user. In all cases, the ghost region is drawn with the values returned by *NEWREGIONFN*. *NEWREGIONFN* can be a list of functions in which case they are called in order with each being passed the result of calling the previous and the value of the last one used as the point.

(**GETBOXREGION** *WIDTH HEIGHT ORGX ORGY WINDOW PROMPTMSG*) [Function]

Performs the same prompting as **GETBOXPOSITION** and returns the **REGION** specified by the user instead of the **POSITION** of its lower left corner.

(**MOUSECONFIRM** *PROMPTSTRING HELPSTRING WINDOW DON'TCLEARWINDOWFLG*) [Function]

**MOUSECONFIRM** provides a simple way for the user to confirm or abort some action simply by using the mouse buttons. It prints the strings *PROMPTSTRING* and *HELPSTRING* in the window *WINDOW*, changes the cursor to a "little mouse" cursor:  (stored in the variable **MOUSECONFIRMCURSOR**), and waits for the user to press the left button to confirm, or any other button to abort. If the left button was the last button released, returns **T**, else **NIL**.

If *PROMPTSTRING* is **NIL**, it is not printed out. If *HELPSTRING* is **NIL**, the string "Click LEFT to confirm, RIGHT to abort." is used. If *WINDOW* is **NIL**, the prompt window is used.

Normally, **MOUSECONFIRM** clears *WINDOW* before returning. If *DON'TCLEARWINDOWFLG* is non-**NIL**, the window is not cleared.

## 28.4 Windows

A window specifies a region of the screen, a display stream, functions that get called when the window undergoes certain actions, and various other items of information. The basic model is that a window is a passive collection of bits (on the screen). On top of this basic level, the system supports many different types of windows that are linked to the data structures displayed in them and provide selection and redisplaying routines. In addition, it is possible for the user to create new types of windows by providing selection and displaying functions for them.

Windows are ordered in depth from user to background. Windows in front of others obscure the latter. Operating on a window generally brings it to the top.

Windows are located at a certain position on the screen. Each window has a clipping region that confines all bits written to it to a region that allows a border around the window, and a title above it.

Each window has a display stream associated with it (see page 27.23), and either a window or its display stream can be passed interchangeably to all system functions. There are dependencies between the window and its display stream that the user should not disturb. For instance, the destination bitmap of the display stream of a window must always be the screen bitmap. The X offset, Y offset, and Clipping Region fields of the display stream should not be changed.

Windows can be created by the user interactively, under program control, or may be created automatically by the system.

Windows are in one of two states: "open" or "closed". In an "open" state, a window is visible on the screen (unless it is covered by other open windows or off the edge of the screen) and accessible to mouse operations. In a "closed" state, a window is not visible and not accessible to mouse operations. Any attempt to print or draw on a closed window will open it.

### 28.4.1 Window Properties

The behavior of a window is controlled by a set of "window properties." Some of these are used by the system. However, any arbitrary property name may be used by a user program to associate information with a window. For many applications the user will associate the structure being displayed with its window using a property. The following functions provide for reading and setting window properties:

**(WINDOWPROP** *WINDOW PROP NEWVALUE***)** [NoSpread Function]

Returns the previous value of *WINDOW*'s *PROP* aspect. If *NEWVALUE* is given, (even if given as **NIL**), it is stored as the new *PROP* aspect. Some aspects cannot be set by the user and will generate errors. Any *PROP* name that is not recognized is stored on a property list associated with the window.

**(WINDOWADDPROP** *WINDOW PROP ITEMTOADD FIRSTFLG***)** [Function]

**WINDOWADDPROP** adds a new item to a window property. If *ITEMTOADD* is **EQ** to an element of the *PROP* property of the window *WINDOW*, nothing is added. If the current property is not a list, it is made a list before *ITEMTOADD* added. **WINDOWADDPROP** returns the previous property. If *FIRSTFLG* is non-**NIL**, the new item goes on the front of the list; otherwise, it goes on the end of the list. If *FIRSTFLG* is non-**NIL** and *ITEMTOADD* is already on the list, it is moved to the front.

Many window properties (**OPENFN**, **CLOSEFN**, etc.) can be a list of functions. **WINDOWADDPROP** is useful for adding additional functions to a window property without affecting any existing functions. Note that if the order of items in a window property is important, the list can be modified using **WINDOWPROP**.

**(WINDOWDELPROP** *WINDOW PROP ITEMTODELETE***)** [Function]

**WINDOWDELPROP** deletes *ITEMTODELETE* from the window property *PROP* of *WINDOW* and returns the previous list if *ITEMTODELETE* was an element. If *ITEMTODELETE* was not a member of window property *PROP*, **NIL** is returned.

### 28.4.2 Creating Windows

**(CREATEW** *REGION TITLE BORDERSIZE NOOPENFLG***)** [Function]

Creates a new window. *REGION* indicates where and how large the window should be by specifying the exterior region of the window. The usable height and width of the resulting window will be smaller than the height and width of the region by twice the border size and further less the height of the title, if any. If

*REGION* is **NIL**, **GETREGION** is called to prompt the user for a region.

If *TITLE* is non-**NIL**, it is printed in the border at the top of the window. The *TITLE* is printed using the global display stream **WindowTitleDisplayStream**. Thus the height of the title will be **(FONTPROP WindowTitleDisplayStream 'HEIGHT)**.

If *BORDERSIZE* is a number, it is used as the border size. If *BORDERSIZE* is not a number, the window will have a border **WBorder** (initially 4) bits wide.

If *NOOPENFLG* is non-**NIL**, the window will not be opened, i.e. displayed on the screen.

The initial X and Y positions of the window are set to the upper left corner by calling **MOVETOUPPERLEFT** (page 27.14).

**(DECODE.WINDOW.ARG** *WHERESPEC WIDTH HEIGHT TITLE BORDER NOOPENFLG***)** [Function]

This is a useful function for creating windows. *WHERESPEC* can be a **WINDOW**, a **REGION**, a **POSITION** or **NIL**. If *WHERESPEC* is a **WINDOW**, it is returned. In all other cases, **CREATEW** is called with the arguments *TITLE BORDER* and *NOOPENFLG*. The *REGION* argument to **CREATEW** is determined from *WHERESPEC* as follows:

If *WHERESPEC* is a **REGION**, it is adjusted to be on the screen, then passed to **CREATEW**.

If *WIDTH* and *HEIGHT* are numbers and *WHERESPEC* is a **POSITION**, the region whose lower left corner is *WHERESPEC*, whose width is *WIDTH* and whose height is *HEIGHT* is adjusted to be on the screen, then passed to **CREATEW**.

If *WIDTH* and *HEIGHT* are numbers and *WHERESPEC* is not a **POSITION**, then **GETBOXREGION** is called to prompt the user for the position of a region that is *WIDTH* by *HEIGHT*.

If *WIDTH* and *HEIGHT* are not numbers, **CREATEW** is given **NIL** as a **REGION** argument.

If *WIDTH* and *HEIGHT* are used, they are used as interior dimensions for the window.

**(WINDOWP** *X***)** [Function]

Returns *X* if *X* is a window, **NIL** otherwise.

### 28.4.3 Opening and Closing Windows

**(OPENWP** ***WINDOW*****)** [Function]

Returns *WINDOW*, if *WINDOW* is an open window (has not been closed); **NIL** otherwise.

**(OPENWINDOWS)** [Function]

Returns a list of all open windows.

**(OPENW** ***WINDOW*****)** [Function]

If *WINDOW* is a closed window, **OPENW** calls the function or functions on the window property **OPENFN** of *WINDOW*, if any. If one of the **OPENFN**s is the atom **DON'T**, the window will not be opened. Otherwise the window is placed on the occlusion stack of windows and its contents displayed on the screen. If *WINDOW* is an open window, it returns **NIL**.

**(CLOSEW** ***WINDOW*****)** [Function]

**CLOSEW** calls the function or functions on the window property **CLOSEFN** of *WINDOW*, if any. If one of the **CLOSEFN**s is the atom **DON'T** or returns the atom **DON'T** as a value, **CLOSEW** returns without doing anything further. Otherwise, **CLOSEW** removes *WINDOW* from the window stack and restores the bits it is obscuring. If *WINDOW* was closed, *WINDOW* is returned as the value. If it was not closed, (for example because its **CLOSEFN** returned the atom **DON'T**), **NIL** is returned as the value.

*WINDOW* can be restored in the same place with the same contents (reopened) by calling **OPENW** or by using it as the source of a display operation.

**OPENFN** [Window Property]

The **OPENFN** window property can be a single function or a list of functions. If one of the **OPENFN**s is the atom **DON'T**, the window will not be opened. Otherwise, the **OPENFN**s are called after a window has been opened by **OPENW**, with the window as a single argument.

**CLOSEFN** [Window Property]

The **CLOSEFN** window property can be a single function or a list of functions that are called just before a window is closed by **CLOSEW**. The function(s) will be called with the window as a single argument. If any of the **CLOSEFN**s are the atom **DON'T**, or if the value returned by any of the **CLOSEFN**s is the atom **DON'T**, the window will not be closed.

Note: If the **CAR** of the **CLOSEFN** list is a **LAMBDA** word, it is treated as a single function.

Note: A **CLOSEFN** should not call **CLOSEW** on its argument.

## 28.4.4 Redisplaying Windows

**(REDISPLAYW** *WINDOW REGION ALWAYSFLG***)** [Function]

Redisplay the region *REGION* of the window *WINDOW*. If *REGION* is **NIL**, the entire window is redisplayed.

If *WINDOW* doesn't have a **REPAINTFN** (page 28.16), the action depends on the value of *ALWAYSFLG*. If *ALWAYSFLG* is **NIL**, *WINDOW* will not change and the message "Window has no REPAINTFN. Can't redisplay." will be printed in the prompt window. If *ALWAYSFLG* is non-**NIL**, **REDISPLAYW** acts as if **REPAINTFN** was **NILL**.

**REPAINTFN** [Window Property]

The **REPAINTFN** window property can be a single function or a list of functions that are called to repaint parts of the window by **REDISPLAYW**. The **REPAINTFN**s are called with two arguments: the window and the region in the coordinates of the window's display stream of the area that should be repainted. Before the **REPAINTFN** is called, the clipping region of the window is set to clip all display operations to the area of interest so that the **REPAINTFN** can display the entire window contents and the results will be appropriately clipped.

Note: **CLEARW** (page 28.31) should not be used in **REPAINTFN**s because it resets the window's coordinate system. If a **REPAINTFN** wants to clear its region first, it should use **DSPFILL** (page 27.20).

## 28.4.5 Reshaping Windows

**(SHAPEW** *WINDOW NEWREGION***)** [Function]

Reshapes *WINDOW*. If the window property **RESHAPEFN** is the atom **DON'T** or a list that contains the atom **DON'T**, a message is printed in the prompt window, *WINDOW* is not changed, and **NIL** is returned. Otherwise, **RESHAPEFN** window property can be a single function or a list of functions that are called when a window is reshaped, to reformat or redisplay the window contents (see below). If the **RESHAPEFN** window property is **NIL**, **RESHAPEBYREPAINTFN** is the default.

If the region *NEWREGION* is **NIL**, it prompts for a region with **GETREGION** (page 28.10). When calling **GETREGION**, the function **MINIMUMWINDOWSIZE** is called to determine the minimum height and width of the window, the function

**WINDOWREGION** is called to get the region passed as the *OLDREGION* argument, the window property **NEWREGIONFN** is used as the **NEWREGIONFN** argument and *WINDOW* as the **NEWREGIONFNARG** argument. If the window property **INITCORNERSFN** is non-**NIL**, it is applied to the window, and the value is passed as the *INITCORNERS* argument to **GETREGION**, to determine the initial size of the "ghost region." These window properties allow the window to specify the regions used for interactive calls to **SHAPEW**.

If the region *NEWREGION* is a **REGION** and its **WIDTH** or **HEIGHT** less than the minimums returned by calling the function **MINIMUMWINDOWSIZE**, they will be increased to the minimums.

If *WINDOW* has a window property **DOSHAPEFN**, it is called, passing it *WINDOW* and *NEWREGION* (or the region returned by **GETREGION**). If *WINDOW* does not have a **DOSHAPEFN** window property, the function **SHAPEW1** is called to reshape the window. **DOSHAPEFNs** are provided to implement window groups and few users should ever write them. They are tricky to write and must call **SHAPEW1** eventually. The **RESHAPEFN** window property is a simpler hook into reshape operations.

**(SHAPEW1 *WINDOW REGION*)** [Function]

Changes *WINDOW*'s size and position on the screen to be *REGION*. After clearing the region on the screen, it calls the window's **RESHAPEFN**, if any, passing it three arguments: (1) *WINDOW*, (2) a bitmap that contains *WINDOW*'s previous screen image and (3) the region of *WINDOW*'s old image within the bitmap.

**RESHAPEFN** [Window Property]

The **RESHAPEFN** window property can be a single function or a list of functions that are called when a window is reshaped by **SHAPEW**. If the **RESHAPEFN** is **DON'T** or a list containing **DON'T**, the window will not be reshaped. Otherwise, the function(s) are called after the window has been reshaped, its coordinate system readjusted to the new position, the title and border displayed, and the interior filled with texture. The **RESHAPEFN** should display any additional information needed to complete the window's image in the new position and shape. The **RESHAPEFN** is called with four arguments: (1) the window in its reshaped form, (2) a bitmap with the image of the old window in its old shape, and (3) the region within the bitmap that contains the window's old image, and (4) the region of the screen previously occupied by this window. This function is provided so that users can reformat window contents or whatever. **RESHAPEBYREPAINTFN** (below) is the default and should be useful for many windows.

**NEWREGIONFN** [Window Property]

If **SHAPEW** calls **GETREGION** to prompt the user for a region, the value of the **NEWREGIONFN** window property is passed as the *NEWREGIONFN* argument to **GETREGION** (page 28.10).

**INITCORNERSFN** [Window Property]

If this window property is non-**NIL**, it should be a function of one argument, a window, that returns a list specifying the initial corners of a "ghost region" of the form **(***BASEX BASEY OPPX OPPY***)**, where (*BASEX*, *BASEY*) describes the anchored corner of the box, and (*OPPX*, *OPPY*) describes the trackable corner. If **SHAPEW** calls **GETREGION** to prompt the user for a region, this function is applied to the window, and the list returned is passed as the *INITCORNERS* argument to **GETREGION** (page 28.10), to specify the initial ghost region.

**DOSHAPEFN** [Window Property]

If this window property is non-**NIL**, it is called by **SHAPEW** to reshape the window (instead of **SHAPEW1**). It is called with two arguments: the window and the new region.

**(RESHAPEBYREPAINTFN** *WINDOW OLDIMAGE IMAGEREGION OLDSCREENREGION***)** [Function]

This the default window **RESHAPEFN**. *WINDOW* is a window that has been reshaped from the screen region *OLDSCREENREGION* to its new region (available via **(WINDOWPROP WINDOW 'REGION))**. *OLDIMAGE* is a bitmap that contains the image of the window from its previous location. *IMAGEREGION* is the region within *OLDIMAGE* that contains the old image.

**RESHAPEBYREPAINTFN BITBLT**s the old region contents into the new region. If the new shape is larger in either or both dimensions, the newly exposed areas are redisplayed via calls *WINDOW*'s **REPAINTFN** window property (page 28.16). **RESHAPEBYREPAINTFN** may call the **REPAINTFN** up to four times during a single reshape.

The choice of which areas of the window to remove or extend is done as follows. If *WINDOW*'s new region shares an edge with *OLDSCREENREGION*, that edge of the window image will remain fixed and any addition or reduction in that dimension will be performed on the opposite side. If *WINDOW* has an **EXTENT** property and the newly exposed window area is outside of it, any extra will be added so as to show **EXTENT** that was previously not visible. An exception to these rules is that the current X,Y position is kept visible, if it was visible before the reshape.

### 28.4.6 Moving Windows

**(MOVEW** ***WINDOW POSorX Y*****)** [Function]

Moves *WINDOW* to the position specified by *POSorX* and *Y* according to the following rules:

If *POSorX* is **NIL**, **GETBOXPOSITION** (page 28.9) is called to read a position from the user. If *WINDOW* has a **CALCULATEREGION** window property, it will be called with *WINDOW* as an argument and should return a region which will be used to prompt the user with. If *WINDOW* does not have a **CALCULATEREGION** window property, the region of *WINDOW* is used to prompt with.

If *POSorX* is a **POSITION**, *POSorX* is used.

If *POSorX* and *Y* are both **NUMBERP**, a position is created using *POSorX* as the **XCOORD** and *Y* as the **YCOORD**.

If *POSorX* is a **REGION**, a position is created using its **LEFT** as the **XCOORD** and **BOTTOM** as the **YCOORD**.

If *WINDOW* is not open and *POSorX* is non-**NIL**, the window will be moved without being opened. Otherwise, it will be opened.

If *WINDOW* has the atom **DON'T** as a **MOVEFN** window property, the window will not be moved. If *WINDOW* has any other non-**NIL** value as a **MOVEFN** property, it should be a function or list of functions that will be called before the window is moved with the *WINDOW* and the new positon as its arguments. If it returns the atom **DON'T**, the window will not be moved. If it returns a position, the window will be moved to that position instead of the new one. If there are more than one **MOVEFN**s, the last one to return a value is the one that determines where the window is moved to.

If *WINDOW* is moved and *WINDOW* has an **AFTERMOVEFN** window property, it should be a function or a list of functions that will be called after the window is moved with *WINDOW* as an argument.

**MOVEW** returns the new position, or **NIL** if the window could not be moved.

Note: If **MOVEW** moves any part of the window from off-screen onto the screen, that part is redisplayed (by calling **REDISPLAYW**).

**(RELMOVEW** ***WINDOW POSITION*****)** [Function]

Like **MOVEW** for moving windows but the *POSITION* is interpreted relative to the current position of *WINDOW*. Example: The following code moves *WINDOW* to the right one screen point.

**(RELMOVEW** *WINDOW* **(create POSITION XCOORD ← 1 YCOORD ← 0))**

**CALCULATEREGION** [Window Property]

If **MOVEW** calls **GETBOXPOSITION** to prompt the user for a region, the **CALCULATEREGION** window property is called (passing the window as an argument. The **CALCULATEREGION** should returns a region to be used to prompt the user with. If **CALCULATEREGION** is **NIL**, the region of the window is used to prompt with.

**MOVEFN** [Window Property]

If the **MOVEFN** is **DON'T**, the window will not be moved by **MOVEW**. Otherwise, if the **MOVEFN** is non-**NIL**, it should be a function or a list of functions that will be called before a window is moved with two arguments: the window being moved and the new position of the lower left corner in screen coordinates. If the **MOVEFN** returns **DON'T**, the window will not be moved. If the **MOVEFN** returns a **POSITION**, the window will be moved to that position. Otherwise, the window will be moved to the specified new position.

**AFTERMOVEFN** [Window Property]

If non-**NIL**, it should be a function or a list of functions that will be called after the window is moved (by **MOVEW**) with the window as an argument.

## 28.4.7 Exposing and Burying Windows

**(TOTOPW** *WINDOW NOCALLTOTOPFNFLG***)** [Function]

Brings *WINDOW* to the top of the stack of overlapping windows, guaranteeing that it is entirely visible. If *WINDOW* is closed, it is opened. This is done automatically whenever a printing or drawing operation occurs to the window.

If *NOCALLTOTOPFNFLG* is **NIL**, the **TOTOPFN** of *WINDOW* is called (page 28.20). If *NOCALLTOTOPFNFLG* is **T**, it is not called, which allows a **TOTOPFN** to call **TOTOPW** without causing an infinite loop.

**(BURYW** *WINDOW***)** [Function]

Puts *WINDOW* on the bottom of the stack by moving all the windows that it covers in front of it.

**TOTOPFN** [Window Property]

If non-**NIL**, whenever the window is brought to the top, the **TOTOPFN** is called (with the window as a single argument). This function may be used to bring a collection of windows to the top together.

If the *NOCALLTOPWFN* argument of **TOTOPW** is non-**NIL**, the **TOTOPFN** of the window is not called, which provides a way of avoiding infinite loops when using **TOTOPW** from within a **TOTOPFN**.

## 28.4.8 Shrinking Windows Into Icons

Occasionally, a user will have a number of large windows on the screen, making it difficult to access those windows being used. To help with the problem of screen space management, the Interlisp-D window system allows the creation of *Icons*. An icon is a small rectangle (containing text or a bitmap) which is a "shrunken-down" form of a particular window. Using the **Shrink** and **Expand** window menu commands (page 28.5), the user can shrink windows not currently being used into icons, and quickly restore the original windows at any time. This facility is controlled by the following functions and window properties:

**(SHRINKW** *WINDOW TOWHAT ICONPOSITION EXPANDFN***)** [Function]

**SHRINKW** makes a small icon which represents *WINDOW* and removes *WINDOW* from the screen. Icons have a different window command menu that contains "**EXPAND**" instead of "**SHRINK**". The **EXPAND** command calls **EXPANDW** which returns the shrunken window to its original size and place. The icon can also be moved by pressing the **LEFT** button in it, or expanded by pressing the **MIDDLE** button in it.

The **SHRINKFN** property of the window *WINDOW* affects the operation of **SHRINKW**. If the **SHRINKFN** property of *WINDOW* is the atom **DON'T**, **SHRINKW** returns. Otherwise, the **SHRINKFN** property of the window is treated as a (list of) function(s) to apply to *WINDOW*; if any returns the atom **DON'T**, **SHRINKW** returns.

*TOWHAT*, if given, indicates the image the icon window will have. If *TOWHAT* is a string, atom or list, the icon's image will be that string (currently implemented as a title-only window with *TOWHAT* as the title.) If *TOWHAT* is a **BITMAP**, the icon's image will be a copy of the bitmap. If *TOWHAT* is a **WINDOW**, that window will be used as the icon.

If *TOWHAT* is not given (as is the case when invoked from the **SHRINK** window command), then the following apply in turn: (1) If the window has an **ICONFN** property, it gets called with the two arguments *WINDOW* and *OLDICON*, where *WINDOW* is the window being shrunk and *OLDICON* is the previously created icon, if any. The **ICONFN** should return one of the *TOWHAT* entities described above or return the *OLDICON* if it does not want to change it. (2) If the window has an **ICON** property, it is used as the value of *TOWHAT*. (3) If the window has neither an

**ICONFN** or **ICON** property, the icon will be *WINDOW*'s title or, if *WINDOW* doesn't have a title, the date and time of the icon creation.

*ICONPOSITION* gives the position that the new icon will be on the screen. If it is **NIL**, the icon will be in the corner of the window furthest from the center of the screen.

In all but the default case, the icon is cached on the property **ICONWINDOW** of *WINDOW* so repeating **SHRINKW** reuses the same icon (unless overridden by the **ICONFN** described above). Thus to change the icon it is necessary to remove the **ICONWINDOW** property or call **SHRINKW** explicitly giving a *TOWHAT* argument.

**(EXPANDW** *ICONW***)** [Function]

Restores the window for which *ICONW* is an icon, and removes the icon from the screen. If the **EXPANDFN** window property of the main window is the atom **DON'T**, the window won't be expanded. Otherwise, the window will be restored to its original size and location and the **EXPANDFN** (or list of functions) will be applied to it.

**SHRINKFN** [Window Property]

The **SHRINKFN** window property can be a single function or a list of functions that are called just before a window is shrunken by **SHRINKW**, with the window as a single argument. If any of the **SHRINKFN**s are the atom **DON'T**, or if the value returned by any of the **SHRINKFN**s is the atom **DON'T**, the window will not be shrunk.

**ICONFN** [Window Property]

If **SHRINKW** is called without begin given a *TOWHAT* argument (as is the case when invoked from the **SHRINK** window command) and the window's **ICONFN** property is non-**NIL**, then it gets called with two arguments, the window being shrunk and the previously created icon, if any. The **ICONFN** should return one of the *TOWHAT* entities described above or return the previously created icon if it does not want to change it.

**ICON** [Window Property]

If **SHRINKW** is called without being given a *TOWHAT* argument, the window's **ICONFN** property is **NIL**, and the **ICON** property is non-**NIL**, then it is used as the value of *TOWHAT*.

**ICONWINDOW** [Window Property]

Whenever an icon is created, it is cached on the property **ICONWINDOW** of the window, so calling **SHRINKW** again will reuse the same icon (unless overridden by the **ICONFN**.

Thus, to change the icon it is necessary to remove the **ICONWINDOW** property or call **SHRINKW** (page 28.21) explicitly giving a *TOWHAT* argument.

**EXPANDFN** [Window Property]

The **EXPANDFN** window property can be a single function or a list of functions. If one of the **EXPANDFN**s is the atom **DON'T**, the window will not be expanded. Otherwise, the **EXPANDFN**s are called after the window has been expanded by **EXPANDW**, with the window as a single argument.

## 28.4.9 Coordinate Systems, Extents, And Scrolling

Note: The word "scrolling" has two distinct meanings when applied to Interlisp-D windows. This section documents the use of "scroll bars" on the left and bottom of a window to move an object displayed in the window. "Scrolling" also describes the feature where trying to print text off the bottom of a window will cause the contents to "scroll up." This second feature is controlled by the function **DSPSCROLL** (page 27.24.

One way of thinking of a window is as a "view" onto an object (e.g. a graph, a file, a picture, etc.) The object has its own natural coordinate system in terms of which its subparts are laid out. When the window is created, the X Offset and Y Offset of the window's display stream are set to map the origin of the object's coordinate system into the lower left point of the window's interior region. At the same time, the Clipping Region of the display stream is set to correspond to the interior of the window. From then on, the display stream's coordinate system is translated and its clipping region adjusted whenever the window is moved, scrolled or reshaped.

There are several distinct regions associated with a window viewing an object. First, there is a region in the window's coordinate system that contains the complete image of the object. This region (which can only be determined by application programs with knowledge of the "semantics" of the object) is stored as the **EXTENT** property of the window (below). Second, the clipping region of the display stream (obtainable with the function **DSPCLIPPINGREGION**, page 27.11) specifies the portion of the object that is actually visible in the window. This is set so that it corresponds to the interior of the window (not including the border or title). Finally, there is the region on the screen that specifies the total area that the window occupies, including the border and title. This region (in screen coordinates) is stored as the **REGION** property of the window (page 28.34).

The window system supports the idea of scrolling the contents of a window. Scrolling regions are on the left and the bottom edge of each window. The **LEFT** key is used to indicate upward or leftward scrolling by the amount necessary to move the selected position to the top or the left edge. The **RIGHT** key is used to indicate downward or rightward scrolling by the amount necessary to move the top or left edge to the selected position. The **MIDDLE** key is used to indicate global placement of the object within the window (similar to "thumbing" a book). In the scroll region, the part of the object that is being viewed by the window is marked with a gray shade. If the whole scroll bar is thought of as the entire object, the shaded portion is the portion currently being viewed. This will only occur when the window "knows" how big the object is (see window property **EXTENT**, page 28.26).

When the button is released in a scroll region, the function **SCROLLW** is called. **SCROLLW** calls the scrolling function associated with the window to do the actual scrolling and provides a programmable entry to the scrolling operation.

**(SCROLLW** ***WINDOW DELTAX DELTAY CONTINUOUSFLG*****)** [Function]

Calls the **SCROLLFN** window property of the window *WINDOW* with arguments *WINDOW*, *DELTAX*, *DELTAY* and *CONTINUOUSFLG*. See **SCROLLFN** window property, page 28.26.

**(SCROLL.HANDLER** ***WINDOW*****)** [Function]

This is the function that tracks the mouse while it is in the scroll region. It is called when the cursor leaves a window in either the left or downward direction. If *WINDOW* does not have a scroll region for this direction (e.g. the window has moved or reshaped since it was last scrolled), a scroll region is created that is **SCROLLBARWIDTH** wide. It then waits for **SCROLLWAITTIME** milliseconds and if the cursor is still inside the scroll region, it opens a window the size of the scroll region and changes the cursor to indicate the scrolling is taking place.

When a button is pressed, the cursor shape is changed to indicate the type of scrolling (up, down, left, right or thumb). After the button is held for **WAITBEFORESCROLLTIME** milliseconds, until the button is released **SCROLLW** is called each **WAITBETWEENSCROLLTIME** milliseconds. These calls are made with the *CONTINUOUSFLG* argument set to **T**. If the button is released before **WAITBEFORESCROLLTIME** milliseconds, **SCROLLW** is called with the *CONTINUOUSFLG* argument set to **NIL**.

The arguments passed to **SCROLLW** depend on the mouse button. If the **LEFT** button is used in the vertical scroll region, *DY* is distance from cursor position at the time the button was released to the top of the window and *DX* is 0. If the **RIGHT** button is used, the inverse of this quantity is used for *DY* and 0 for *DX*. If the **LEFT** button is used in the horizontal scroll region, *DX* is distance from cursor position to left of the window and *DY* is 0. If the **RIGHT** button is used, the inverse of this quantity is used for *DX* and 0 for *DY*.

If the **MIDDLE** button is pressed, the distance argument to **SCROLLW** will be a **FLOATP** between 0.0 and 1.0 that indicates the proportion of the distance the cursor was from the left or top edge to the right or bottom edge.

Note: The scrolling regions will not come up if the window has a **SCROLLFN** window property of **NIL**, has a non-**NIL** **NOSCROLLBARS** window property, or if its **SCROLLEXTENTUSE** (page 28.26) property has certain values and its **EXTENT** is fully visible.

**(SCROLLBYREPAINTFN** *WINDOW DELTAX DELTAY CONTINUOUSFLG***)** [Function]

**SCROLLBYREPAINTFN** is the standard scrolling function which should be used as the **SCROLLFN** property for most scrolling windows.

This function, when used as a **SCROLLFN**, **BITBLT**s the bits that will remain visible after the scroll to their new location, fills the newly exposed area with texture, adjusts the window's coordinates and then calls the window's **REPAINTFN** on the newly exposed region. Thus this function will scroll any window that has a repaint function.

If *WINDOW* has an **EXTENT** property (page 28.26), **SCROLLBYREPAINTFN** will limit scrolling in the X and Y directions according to the value of the window property **SCROLLEXTENTUSE** (page 28.26).

If *DELTAX* or *DELTAY* is a **FLOATP**, **SCROLLBYREPAINTFN** will position the window so that its top or left edge will be positioned at that proportion of its **EXTENT**. If the window does not have an **EXTENT**, **SCROLLBYREPAINTFN** will do nothing.

If *CONTINUOUSFLG* is non-**NIL**, this indicates that the scrolling button is being held down. In this case, **SCROLLBYREPAINTFN** will scroll the distance of one linefeed height (as returned by **DSPLINEFEED**, page 27.12).

Scrolling is controlled by the following window properties:

**EXTENT** [Window Property]

Used to limit scrolling operations. Accesses the extent region of the window. If non-**NIL**, the **EXTENT** is a region in the window's display stream that contains the complete image of the object being viewed by the window. User programs are responsible for updating the **EXTENT**. The functions **UNIONREGIONS**, **EXTENDREGION**, etc. (page 27.2) are useful for computing a new extent region.

In some situations, it is useful to define an **EXTENT** that only exists in one dimension. This may be done by specifying an **EXTENT** region with a width or height of **-1**. **SCROLLFN** handling recognizes this situation as meaning that the negative **EXTENT** dimension is unknown.

**SCROLLFN** [Window Property]

If the **SCROLLFN** property is **NIL**, the window will not scroll. Otherwise, it should be a function of four arguments: (1) the window being scrolled, (2) the distance to scroll in the horizontal direction (positive to right, negative to left), (3) the distance to scroll in the vertical direction (positive up, negative down), and (4) a flag which is **T** if the scrolling button is being held down. For more information, see **SCROLL.HANDLER** (page 28.24). For most scrolling windows, the **SCROLLFN** function should be **SCROLLBYREPAINTFN** (page 28.25).

**NOSCROLLBARS** [Window Property]

If the **NOSCROLLBARS** property is non-**NIL**, scroll bars will not be brought up for this window. This disables mouse-driven scrolling of a window. This window can still be scrolled using **SCROLLW** (page 28.24).

**SCROLLEXTENTUSE** [Window Property]

**SCROLLBYREPAINTFN** uses the **SCROLLEXTENTUSE** window property to limit how far scrolling can go in the X and Y directions. The possible values for **SCROLLEXTENTUSE** and their interpretations are:

**NIL** This will keep the extent region visible or near visible. It will not scroll the window so that the top of the extent is below the top of the window, the bottom of the extent is more than one point above the top of the window, the left of the extent is to the right of the window and the right of the extent is to the left of the window. The **EXTENT** can be scrolled to just above the window to provide a way of "hiding" the contents of a window. In this mode the extent is either in the window or just of the top of the window.

**T** The extent is not used to control scrolling. The user can scroll the window to anywhere. Having the **EXTENT** window property does all thumb scrolling to be supported so that the user can get back to the EXTENT by thumb scrolling.

**LIMIT** This will keep the extent region visible. The window is only allowed to view within the extent.

**+** This will keep the extent region visible or just off in the positive direction in either X or Y (i.e. the image will be either be visible or just off to the top and/or right.)

**-** This will keep the extent region visible or just off in the negative direction in either X or Y (i.e. the image will be either be visible or just off to the left and/or bottom).

**+-**
**-+** This will keep the extent region visible or just off in the window (i.e. the image will be either be visible or just off to the left, bottom, top or right).

(*XBEHAVIOR* . *YBEHAVIOR*) If the **SCROLLEXTENTUSE** is a list, the **CAR** is interpreted as the scrolling limit in the X behavior and the **CDR** as the scrolling limit in the Y behavior. *XBEHAVIOR* and *YBEHAVIOR* should each be one of the atoms **(NIL T LIMIT + - +- -+)**. The interpretations of the atoms is the same as above except that **NIL** is equivalent to **LIMIT**.

Note: The **NIL** value of **SCROLLEXTENTUSE** is equivalent to **(LIMIT . +)**.

Example: If the **SCROLLEXTENTUSE** window property of a window (with an extent defined) is **(LIMIT . T)**, the window will scroll uncontrolled in the Y dimension but be limited to the extent region in the X dimension.

## 28.4.10 Mouse Activity in Windows

The following window properties allow the user to control the response to mouse activity in a window. The value of these properties, if non-**NIL**, should be a function that will be called (with the window as argument) when the specified event occurs.

Note: these functions should be "self-contained", communicating with the outside world solely via their window argument, e.g., by setting window properties. In particular, these functions should not expect to access variables bound on the stack, as the stack context is formally undefined at the time these functions are called. Since the functions are invoked asynchronously, they perform any terminal input/output operations from their own window.

**WINDOWENTRYFN** [Window Property]

Whenever a button goes down in the window and the process associated with the window is not the tty process, the

**WINDOWENTRYFN** is called. The default is **GIVE.TTY.PROCESS** (page 23.13) which gives the process associated with the window the tty and calls the **BUTTONEVENTFN**. **WINDOWENTRYFN** can be a list of functions and all will be called.

**CURSORINFN** [Window Property]

Whenever the mouse moves into the window, the **CURSORINFN** is called. If **CURSORINFN** is a list of functions, all will be called.

**CURSOROUTFN** [Window Property]

The **CURSOROUTFN** is called when the cursor leaves the window. If **CURSOROUTFN** is a list of functions, all will be called.

**CURSORMOVEDFN** [Window Property]

The **CURSORMOVEDFN** is called whenever the cursor has moved and is inside the window. **CURSORMOVEDFN** can be a list of functions and all will be called. This allows a window function to implement "active" regions within itself by having its **CURSORMOVEDFN** determine if the cursor is in a region of interest, and if so, perform some action.

**BUTTONEVENTFN** [Window Property]

The **BUTTONEVENTFN** is called whenever there is a change in the state (up or down) of the mouse buttons inside the window. Changes to the mouse state while the **BUTTONEVENTFN** is running will not be interpreted as new button events, and the **BUTTONEVENTFN** will not be re-invoked.

**RIGHTBUTTONFN** [Window Property]

The **RIGHTBUTTONFN** is called in lieu of the standard window menu operation **(DOWINDOWCOM)** when the **RIGHT** key is depressed in a window. More specifically, the **RIGHTBUTTONFN** is called instead of the **BUTTONEVENTFN** when **(MOUSESTATE (ONLY RIGHT))**. If the **RIGHT** key is to be treated like any other key in a window, supply **RIGHTBUTTONFN** and **BUTTONEVENTFN** with the same function.

When an application program defines its own **RIGHTBUTTONFN**, there is a convention that the default **RIGHTBUTTONFN**, **DOWINDOWCOM** (page 28.7), may be executed by depressing the **RIGHT** key when the cursor is in the header or border of a window. User **RIGHTBUTTONFN**s are encouraged to follow this convention, by calling **DOWINDOWCOM** if the cursor is not in the interior region of the window.

**BACKGROUNDBUTTONEVENTFN** [Variable]

**BACKGROUNDCURSORINFN** [Variable]

**BACKGROUNDCURSOROUTFN** [Variable]

**BACKGROUNDCURSORMOVEDFN** [Variable]

These variables provide a way of taking action when there is cursor action and the cursor in in the background. They are interpreted like the corresponding window properties. If set to the name of a function, that function will be called, respectively, whenever the cursor is in the background and a button changes, when the cursor moves into the background from a window, when the cursor moved from the background into a window and when the cursor moves from one place in the background to another.

## 28.4.11 Terminal I/O and Page Holding

Each process has its own terminal i/o stream (accessed as the stream **T**, page 25.1). The terminal i/o stream for the current process can be changed to point to a window by using the function **TTYDISPLAYSTREAM**, so that output and echoing of type-in is directed to a window.

**(TTYDISPLAYSTREAM** *DISPLAYSTREAM***)** [Function]

Selects the display stream or window *DISPLAYSTREAM* to be the terminal output channel, and returns the previous terminal output display stream. **TTYDISPLAYSTREAM** puts *DISPLAYSTREAM* into scrolling mode and calls **PAGEHEIGHT** with the number of lines that will fit into *DISPLAYSTREAM* given its current Font and Clipping Region. The line length of **TTYDISPLAYSTREAM** is computed (like any other display stream) from its Left Margin, Right Margin, and Font. If one of these fields is changed, its line length is recalculated. If one of the fields used to compute the number of lines (such as the Clipping Region or Font) changes, **PAGEHEIGHT** is not automatically recomputed. **(TTYDISPLAYSTREAM (TTYDISPLAYSTREAM))** will cause it to be recomputed.

If the window system is active, the line buffer is saved in the old **TTY** window, and the line buffer is set to the one saved in the window of the new display stream, or to a newly created line buffer (if it does not have one). Caution: It is possible to move the **TTYDISPLAYSTREAM** to a nonvisible display stream or to a window whose current position is not in its clipping region.

**(PAGEHEIGHT *N*)** [Function]

If *N* is greater than 0, it is the number of lines of output that will be printed to **TTYDISPLAYSTREAM** before the page is held. A page is held before the *N*+1 line is printed to **TTYDISPLAYSTREAM** without intervening input if there is no terminal input waiting to be read. The output is held with the screen video reversed until a character is typed. Output holding is disabled if *N* is 0. **PAGEHEIGHT** returns the previous setting.

**PAGEFULLFN** [Window Property]

If the **PAGEFULLFN** window property is non-**NIL**, it will be called with the window as a single argument when the window is full (i.e., when enough has been printed since the last **TTY** interaction so that the next character printed will cause information to be scrolled off the top of the window.)

If the **PAGEFULLFN** window property is **NIL**, the system function **PAGEFULLFN** is called. **PAGEFULLFN** simply returns if there are characters in the type-in buffer for *WINDOW*, otherwise it inverts the window and waits for the user to type a character. **PAGEFULLFN** is user advisable.

Note: The **PAGEFULLFN** window property is only called on windows which are the **TTYDISPLAYSTREAM** of some process.

## 28.4.12 The TTY Process and the Caret

At any time, one process is designated as the TTY process, which is used for accepting keyboard input. The TTY process can be changed to a given process by calling **GIVE.TTY.PROCESS** (page 23.13), or by clicking the mouse in a window associated with the process. The latter mechanism is implemented with the following window property:

**PROCESS** [Window Property]

If the **PROCESS** window property is non-**NIL**, it should be a **PROCESS** and will be made the TTY process by **GIVE.TTY.PROCESS** (page 23.13), the default **WINDOWENTRYFN** property (page 28.27). This implements the mechanism by which the keyboard is associated with different processes.

The window system uses a flashing caret (^) to indicate the position of the next window typeout. There is only one caret visible at any one time. The caret in the current TTY process is always visible; if it is hidden by another window, its window is brought to the top. An exception to this rule is that the flashing caret's window is not brought to the top if the user is buttoning or has a shift key down. This prevents the destination window (which has the tty and caret flashing) from interfering with the window one is trying to select text to copy from.

**(CARET** *NEWCARET***)** [Function]

Sets the shape that blinks at the location of the next output to the current process. *NEWCARET* should be one of the following:

a **CURSOR** object — If *NEWCARET* is a **CURSOR** object (see page 30.14), it is used to give the new caret shape

**OFF** — Turns the caret off

**NIL** — The caret is not changed. **CARET** returns a **CURSOR** representing the current caret

**T** — Reset the caret to the value of **DEFAULTCARET**. **DEFAULTCARET** can be set to change the initial caret for new processes.

The hotspot of *NEWCARET* indicates which point in the new caret bitmap should be located at the current output position. The previous caret is returned. Note: the bitmap for the caret is not limited to the dimensions **CURSORWIDTH** by **CURSORHEIGHT**.

**(CARETRATE** *ONRATE OFFRATE***)** [Function]

Sets the rate at which the caret for the current process will flash. The caret will be visible for *ONRATE* milliseconds, then not visible for *OFFRATE* milliseconds. If *OFFRATE* is **NIL** then it is set to be the same as *ONRATE*. If *ONRATE* is **T**, both the "on" and "off" times are set to the value of the variable **DEFAULTCARETRATE** (initially 333). The previous value of **CARETRATE** is returned. If the caret is off, **CARETRATE** return NIL.

## 28.4.13 Miscellaneous Window Functions

**(CLEARW** *WINDOW***)** [Function]

Fills *WINDOW* with its background texture, changes its coordinate system so that the origin is the lower left corner of the window, sets its X position to the left margin and sets its Y position to the base line of the uppermost line of text, ie. the top of the window less the font ascent.

**(INVERTW** *WINDOW SHADE***)** [Function]

Fills the window *WINDOW* with the texture *SHADE* in **INVERT** mode. If *SHADE* is **NIL**, **BLACKSHADE** is used. **INVERTW** returns *WINDOW* so that it can be used inside **RESETFORM**.

**(FLASHWINDOW** *WIN? N FLASHINTERVAL SHADE***)** [Function]

Flashes the window *WIN?* by "inverting" it twice. *N* is the number of times to flash the window (default is 1). *FLASHINTERVAL* is the length of time in milliseconds to wait between flashes (default is 200). *SHADE* is the shade that will be used to invert the window (default is **BLACKSHADE**).

If *WIN?* is **NIL**, the whole screen is flashed. In this case, the *SHADE* argument is ignored (can only invert the screen).

**(WHICHW** *X Y***)** [Function]

Returns the window which contains the position in screen coordinates of *X* if *X* is a **POSITION**, the position (*X*,*Y*) if *X* and *Y* are numbers, or the position of the cursor if *X* is **NIL**. Returns **NIL** if the coordinates are not in any window. If they are in more than one window, it returns the uppermost.

Example: **(WHICHW)** returns the window that the cursor is in.

**(DECODE/WINDOW/OR/DISPLAYSTREAM** *DSORW WINDOWVAR TITLE BORDER***)** [Function]

Returns a display stream as determined by the *DSORW* and *WINDOWVAR* arguments. If *DSORW* is a display stream, it is returned. If *DSORW* is a window, its display stream is returned. If *DSORW* is **NIL**, the litatom *WINDOWVAR* is evaluated. If its value is a window, its display stream is returned. If its value is not a window, *WINDOWVAR* is set to a newly created window (prompting user for region) whose display stream is then returned. If *DSORW* is **NEW**, the display stream of a newly created window is returned. If a window is involved in the decoding, it is opened and if *TITLE* or *BORDER* are given, the **TITLE** or **BORDER** property of the window are reset. The *DSORW* = **NIL** case is most useful for programs that want to display their output in a window, but want to reuse the same window each time they are called. The non-**NIL** cases are good for decoding a display stream argument passed to a function.

**(WIDTHIFWINDOW** *INTERIORWIDTH BORDER***)** [Function]

Returns the width of the window necessary to have *INTERIORWIDTH* points in its interior if the width of the border is *BORDER*. If *BORDER* is **NIL**, the default border size **WBorder** is used.

**(HEIGHTIFWINDOW** *INTERIORHEIGHT TITLEFLG BORDER***)** [Function]

Returns the height of the window necessary to have *INTERIORHEIGHT* points in its interior with a border of *BORDER* and, if *TITLEFLG* is non-**NIL**, a title. If *BORDER* is **NIL**, the default border size **WBorder** is used.

**WIDTHIFWINDOW** and **HEIGHTIFWINDOW** are useful for calculating the width and height for a call to **GETBOXPOSITION** for the purpose of positioning a prospective window.

**(MINIMUMWINDOWSIZE** *WINDOW***)** [Function]

Returns a dotted pair, the **CAR** of which is the minimum width *WINDOW* needs and the **CDR** or which is the minimum height *WINDOW* needs.

The minimum size is determined by the value of the window property **MINSIZE** of *WINDOW*. If the value of the **MINSIZE** window property is **NIL**, the width is 26 and the height is the height *WINDOW* needs to have its title, border and one line of text visible. If **MINSIZE** is a dotted pair, it is returned. If it is a litatom, it should be a function which is called with **WINDOW** as its first argument, which should return a dotted pair.

## 28.4.14 Miscellaneous Window Properties

**TITLE** [Window Property]

Accesses the title of the window. If a title is added to a window whose title is **NIL** or the title is removed (set to **NIL**) from a window with a title, the window's exterior (its region on the screen) is enlarged or reduced to accomodate the change without changing the window's interior. For example, **(WINDOWPROP** *WINDOW* **'TITLE "Results")** changes the title of *WINDOW* to be "Results". **(WINDOWPROP** *WINDOW* **'TITLE NIL)** removes the title of *WINDOW*.

**BORDER** [Window Property]

Accesses the width of the border of the window. The border will have at most 2 point of white (but never more than half) and the rest black. The default border is the value of the global variable **WBorder** (initially 4).

**WINDOWTITLESHADE** [Window Property]

Accesses the window title shade of the window. If non-**NIL**, it should be a texture which is used as the "backgound texture" for the title bar on the top of the window. If it is **NIL**, the value of the global variable **WINDOWTITLESHADE** (initially **BLACKSHADE**) is used. Note that black is always used as the background of the title printed in the title bar, so that the letters can be read. The remaining space is painted with the "title shade".

**HARDCOPYFN** [Window Property]

If non-**NIL**, it should be a function that is called by the window menu command **Hardcopy** (page 28.4) to print the contents of a window. The **HARDCOPYFN** property is called with two arguments, the window and an image stream to print to. If the window does not have a **HARDCOPYFN**, the bitmap image of the window (including the border and title) are printed on the file or printer.

**DSP** [Window Property]

Value is the display stream of the window. All system functions will operate on either the window or its display stream. This window property cannot be changed using **WINDOWPROP**.

**HEIGHT** [Window Property]

**WIDTH** [Window Property]

Value is the height and width of the interior of the window (the usable space not counting the border and title). These window properties cannot be changed using **WINDOWPROP**.

**REGION** [Window Property]

Value is a region (in screen coordinates) indicating where the window (counting the border and title) is located on the screen. This window property cannot be changed using **WINDOWPROP**.

## 28.4.15 Example: A Scrollable Window

The following is a simple example showing how one might create a scrollable window.

**CREATE.PPWINDOW** creates a window that displays the pretty printed expression **EXPR**. The window properties **PPEXPR**, **PPORIGX**, and **PPORIGY** are used for saving this expression, and the initial window position. Using this information, **REPAINT.PPWINDOW** simply reinitializes the window position, and prettyprints the expression again. Note that the whole expression is reformatted every time, even if only a small part actually lies within the window. If this window was going to be used to display very large structures, it would be desirable to implement a more sophisticated **REPAINTFN** that only redisplays that part of the expression within the window. However, this scheme would be satisfactory if most of the items to be displayed are small.

**RESHAPE.PPWINDOW** resets the window (and stores the initial window position), calls **REPAINT.PPWINDOW** to display the window's expression, and then sets the **EXTENT** property of the window so that **SCROLLBYREPAINTFN** will be able to handle scrolling and "thumbing" correctly.

```
(DEFINEQ

(CREATE.PPWINDOW
 [LAMBDA (EXPR)              (* rrb " 4-OCT-82 12:06")
                             (* creates a window that displays
                              a pretty printed expression.)

  (PROG (WINDOW)
                             (* ask the user for a piece of the
                              screen and make it into a window.)
     (SETQ WINDOW (CREATEW NIL "PP window"))
                             (* put the expression on the
                              property list of the window so that
                              the repaint and reshape functions
                              can access it.)
     (WINDOWPROP WINDOW (QUOTE PPEXPR) EXPR)
                             (* set the repaint and reshape
                              functions.)
     (WINDOWPROP WINDOW (QUOTE REPAINTFN)
           (FUNCTION REPAINT.PPWINDOW))
     (WINDOWPROP WINDOW (QUOTE RESHAPEFN)
           (FUNCTION RESHAPE.PPWINDOW))
                             (* make the scroll function
                              SCROLLBYREPAINTFN, a system
                              function that uses the repaint
                              function to do scrolling.)
     (WINDOWPROP WINDOW (QUOTE SCROLLFN)
           (FUNCTION SCROLLBYREPAINTFN))
                             (* call the reshape function to
                              initially print the expression and
                              calculate its extent.)
     (RESHAPE.PPWINDOW WINDOW)
     (RETURN WINDOW])


(REPAINT.PPWINDOW
 [LAMBDA (WINDOW REGION)         (* rrb " 4-OCT-82 11:52")

     (* the repainting function for a window with a
      pretty printed expression. This repainting
      function ignores the region to be repainted
      and repaints the entire window.)

                             (* set the window position to the
                              beginning of the pretty printing
                              of the expression.)
```

```
(MOVETO (WINDOWPROP WINDOW (QUOTE PPORIGX))
    (WINDOWPROP WINDOW (QUOTE PPORIGY))
    WINDOW)
(PRINTDEF (WINDOWPROP WINDOW (QUOTE PPEXPR))
     0 NIL NIL NIL WINDOW])


(RESHAPE.PPWINDOW
 [LAMBDA (WINDOW)           (* rrb " 4-OCT-82 12:01")
                    (* the reshape function for a
                     window with a pretty printed
                     expression.)
  (PROG (BTM)

    (* set the position of the window so that the
     first character appears in the upper left corner
     and save the X and Y for the repaint function.)

    (DSPRESET WINDOW)
    (WINDOWPROP WINDOW (QUOTE PPORIGX)
        (DSPXPOSITION NIL WINDOW))
    (WINDOWPROP WINDOW (QUOTE PPORIGY)
        (DSPYPOSITION NIL WINDOW))
                    (* call the repaint function to
                     pretty print the expression in
                     the newly cleared window.)
    (REPAINT.PPWINDOW WINDOW)

    (* save the region actually covered by the pretty
     printed expression so that the scrolling routines
     will know where to stop.  The pretty printing of
     the expression does a carriage return after the
     last piece of the expression printed so that the
     current position is the base line of the next line
     of text.  Hence the last visible piece of the
     expression (BTM) is the ending position plus the
     height of the font above the base line (its ASCENT).)

    (WINDOWPROP WINDOW (QUOTE EXTENT)
     (create REGION
        LEFT ← 0
        BOTTOM ← [SETQ BTM (IPLUS
                    (DSPYPOSITION NIL WINDOW)
                    (FONTPROP WINDOW (QUOTE ASCENT]
        WIDTH ←(WINDOWPROP WINDOW (QUOTE WIDTH))
        HEIGHT ←(IDIFFERENCE
                    (WINDOWPROP WINDOW (QUOTE
HEIGHT))
                    BTM])
```

## 28.5 Menus

A menu is basically a means of selecting from a list of items. The system provides common layout and interactive user selection mechanisms, then calls a user-supplied function when a selection has been confirmed. The two major constituents of a menu are a list of items and a "when selected function." The label that appears for each item is the item itself for non-lists, or its **CAR** if the item is a list. In addition, there are a multitude of different formatting parameters for specifying font, size, and layout. When a menu is created, its unspecified fields are filled with defaults and its screen image is computed and saved.

Menus can be either pop up or fixed. If fixed menus are used, the menu must be included in a window.

**(MENU** *MENU POSITION RELEASECONTROLFLG* **—)** [Function]

This function provides menus that pop up when they are used. It displays *MENU* at *POSITION* (in screen coordinates) and waits for the user to select an item with a mouse key. Before any mouse key is pressed, the item the mouse is over is boxed. After any key is down, the selected menu item is video reversed. When all keys are released, *MENU*'s **WHENSELECTEDFN** field is called with four arguments: (1) the item selected, (2) the menu, (3) the last mouse key released (**LEFT**, **MIDDLE**, or **RIGHT**), and (4) the reverse list of superitems rolled through when selecting the item and **MENU** returns its value. If no item is selected, **MENU** returns **NIL**. If *POSITION* is **NIL**, the menu is brought up at the value from *MENU*'s **MENUPOSITION** field, if it is a **POSITION**, or at the current cursor position. The orientation of *MENU* with respect to the specified position is determined by its **MENUOFFSET** field.

If *RELEASECONTROLFLG* is **NIL**, this process will retain control of the mouse. In this case, if the user lets the mouse key up outside of the menu, **MENU** return **NIL**. (Note: this is the standard way of allowing the user to indicate that they do not want to make the offered choice.) If *RELEASECONTROLFLG* is non-**NIL**, this process will give up control of the mouse when it is outside of the menu so that other processes can be run. In this case, clicking outside the menu has no effect on the call to **MENU**. If the menu is closed (for example, by right buttoning in it and selecting "**Close**" from the window menu), **MENU** returns **NIL**. Programmers are encouraged to provide a menu item such as "cancel" or "abort" which gives users a positive way of indicating "no choice".

Note: A "released" menu will stay visible (on top of the window stack) until it is closed or an item is selected.

**(ADDMENU** *MENU WINDOW POSITION DONTOPENFLG***)** [Function]

This function provides menus that remain active in windows. **ADDMENU** displays *MENU* at *POSITION* (in window coordinates) in *WINDOW*. If the window is too small to display the entire menu, the window is made scrollable. When an item is selected, the value of the **WHENSELECTEDFN** field of *MENU* is called with three arguments: (1) the item selected, (2) the menu, and (3) the mouse key that the item was selected with (**LEFT**, **MIDDLE**, or **RIGHT**). More than one menu can be put in a window, but a menu can only be added to one window at a time. **ADDMENU** returns the window into which *MENU* is placed.

If *WINDOW* is **NIL**, a window is created at the position specified by *POSITION* (in screen coordinates) that is the size of *MENU*. If a window is created, it will be opened unless *DONTOPENFLG* is non-**NIL**. If *POSITION* is **NIL**, the menu is brought up at the value of *MENU*'s **MENUPOSITION** field (in window coordinates), if it is a position, or else in the lower left corner of *WINDOW*. If both *WINDOW* and *POSITION* are **NIL**, a window is created at the current cursor position.

Warning: **ADDMENU** resets several of the window properties of *WINDOW*. The **CURSORINFN**, **CURSORMOVEDFN**, and **BUTTONEVENTFN** window properties are replaced with **MENUBUTTONFN**, so that *MENU* will be active. **MENUREPAINTFN** is added to the **REPAINTFN** window property to update the menu image if the window is redisplayed. The **SCROLLFN** window property is changed to **SCROLLBYREPAINTFN** if the window is too small for the menu, to make the window scroll.

**(DELETEMENU** *MENU CLOSEFLG FROMWINDOW***)** [Function]

This function removes *MENU* from the window *FROMWINDOW*. If *MENU* is the only menu in the window and *CLOSEFLG* is non-**NIL**, its window will be closed (by **CLOSEW**).

If *FROMWINDOW* is **NIL**, the list of currently open windows is searched for one that contains *MENU*. If none is found, **DELETEMENU** does nothing.

## 28.5.1 Menu Fields

A menu is a datatype with the following fields:

**ITEMS** [Menu Field]

The list of items to appear in the menu. If an item is a list, its **CAR** will appear in the menu. If the item (or its **CAR**) is a bitmap, the bitmap will be displayed in the menu. The default selection functions interpret each item as a list of three elements: a label, a form whose value is returned upon selection, and a help string that is printed in the prompt window when the user presses a mouse key with the cursor pointing to this item. The default subitem function interprets the fourth element of the list. If it is a list whose **CAR** is the litatom **SUBITEMS** , the **CDR** is taken as a list of subitems.

**SUBITEMFN** [Menu Field]

A function to be called to determine if an item has any subitems. If an item has subitems and the user rolls the cursor out the right of that item, a submenu with that item's subitems in it pops up. If the user selects one of the items from the submenu, the selected subitem is handled as if it were selected from the main menu. If the user rolls out of the submenu to the left, the submenu is taken down and selection resumes from the main menu.

An item with subitems is marked in the menu by a grey, right pointing triangle following the label.

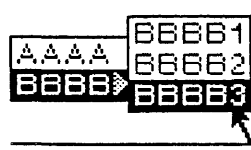
The function is called with two arguments: (1) the menu and (2) the item. It should return a list of the subitems of this item if any. (Note: it is called twice to compute the menu image and each time the user rolls out of the item box so it should be moderately efficient. The default **SUBITEMFN, DEFAULTSUBITEMFN**, checks to see if the item is a list whose fourth element is a list whose **CAR** is the litatom **SUBITEMS** and if so, returns the **CDR** of it.

For example:

```
(create MENU
   ITEMS ←'(AAAA (BBBB 'BBBB "help string for BBBB"
            (SUBITEMS BBBB1 BBBB2 BBBB3))))
```

will create a menu with items **A** and **B** in which **B** will have subitems **B1**, **B2** and **B3**. The following picture below shows this menu as it first appears:


The following picture shows the submenu, with the item **BBBB3** selected by the cursor (↖):



**WHENSELECTEDFN** [Menu Field]

A function to be called when an item is selected. The function is called with three arguments: (1) the item selected, (2) the menu, and (3) the mouse key that the item was selected with (**LEFT**, **MIDDLE**, or **RIGHT**). The default function **DEFAULTWHENSELECTEDFN** evaluates and returns the value of the second element of the item if the item is a list of at least length 2. If the item is not a list of at least length 2, **DEFAULTWHENSELECTEDFN** returns the item.

Note: If the menu is added to a window with **ADDMENU**, the default **WHENSELECTEDFN** is **BACKGROUNDWHENSELECTEDFN**, which is the same as **DEFAULTWHENSELECTEDFN** except that **EVAL.AS.PROCESS** (page 23.17) is used to evaluate the second element of the item, instead of tying up the mouse process.

**WHENHELDFN** [Menu Field]

The function which is called when the user has held a mouse key on an item for **MENUHELDWAIT** milliseconds (initially 1200). The function is called with three arguments: (1) the item selected, (2) the menu, and (3) the mouse key that the item was selected with (**LEFT**, **MIDDLE**, or **RIGHT**). **WHENHELDFN** is intended for prompting users. The default is **DEFAULTMENUHELDFN** which prints (in the prompt window) the third element of the item or, if there is not a third element, the string "This item will be selected when the button is released."

**WHENUNHELDFN** [Menu Field]

If **WHENHELDFN** was called, **WHENUNHELDFN** will be called: (1) when the cursor leaves the item, (2) when a mouse key is released, or (3) when another key is pressed. The function is called with the same three argument values used to call **WHENHELDFN**. The default **WHENUNHELDFN** is the function **CLRPROMPT** (page 28.3), which just clears the prompt window.

**MENUPOSITION** [Menu Field]

The position of the menu to be used if the call to **MENU** or **ADDMENU** does not specify a position. For popup menus, this is in screen coordinates. For fixed menus, it is in the coordinates of the window the menu is in. The point within the menu image that is placed at this position is determined by **MENUOFFSET**. If **MENUPOSITION** is **NIL**, the menu will be brought up at the cursor position.

**MENUOFFSET** [Menu Field]

The position in the menu image that is to be located at **MENUPOSITION**. The default offset is (0,0). For example, to bring up a menu with the cursor over a particular menu item, set its **MENUOFFSET** to a position within that item and set its **MENUPOSITION** to **NIL**.

**MENUFONT** [Menu Field]

The font in which the items will be appear in the menu. Default is the value of **MENUFONT**.

**TITLE** [Menu Field]

If non-**NIL**, the value of this field will appear as a title in a line above the menu.

**MENUTITLEFONT** [Menu Field]

The font in which the title of the menu will be appear. If this is **NIL**, the title will be in the same font as window titles. If it is **T**, it will be in the same font as the menu items.

**CENTERFLG** [Menu Field]

If non-**NIL**, the menu items are centered; otherwise they are left-justified.

**MENUROWS** [Menu Field]

**MENUCOLUMNS** [Menu Field]

These fields control the shape of the menu in terms of rows and columns. If **MENUROWS** is given, the menu will have that number of rows. If **MENUCOLUMNS** is given, the menu will have that number of columns. If only one is given, the other one will be calculated to generate the minimal rectangular menu. (Normally only one of **MENUROWS** or **MENUCOLUMNS** is given.) If neither is given, the items will be in one column.

**ITEMHEIGHT** [Menu Field]

The height of each item box in the menu. If not specified, it will be the maximum of the height of the **MENUFONT** and the heights of any bitmaps appearing as labels.

**ITEMWIDTH** [Menu Field]

The width of each item box in the menu. If not specified, it will be the width of the largest item in the menu.

**MENUBORDERSIZE** [Menu Field]

The size of the border around each item box. If not specified, 0 (no border) is used.

**MENUOUTLINESIZE** [Menu Field]

The size of the outline around the entire menu. If not specified, a maximum of 1 and the **MENUBORDERSIZE** is used.

**CHANGEOFFSETFLG** [Menu Field]

(popup menus only) If **CHANGEOFFSETFLG** is non-**NIL**, the position of the menu offset is set each time a selection is confirmed so that the menu will come up next time in the same position relative to the cursor. This will cause the menu to reappear in the same place on the screen if the cursor has not moved since the last selection. This is implemented by changing the **MENUOFFSET** field on each use. If **CHANGEOFFSETFLG** is the atom **X** or the atom **Y**, only the X or the Y coordinate of the **MENUOFFSET** field will be changed. For example, by setting the **MENUOFFSET** position to (-1,0) and setting **CHANGEOFFSETFLG** to **Y**, the menu will pop up so that the cursor is just to the left of the last item selected. This is the setting of the window command menus.

The following fields are read only.

**IMAGEHEIGHT** [Menu Field]

Returns the height of the entire menu.

**IMAGEWIDTH** [Menu Field]

Returns the width of the entire menu.

## 28.5.2 Miscellaneous Menu Functions

**(MAXMENUITEMWIDTH** *MENU***)** [Function]

Returns the width of the largest menu item label in the menu *MENU*.

**(MAXMENUITEMHEIGHT** *MENU***)** [Function]

Returns the height of the largest menu item label in the menu *MENU*.

**(MENUREGION** *MENU***)** [Function]

Returns the region covered by the image of *MENU* in its window.

**(WFROMMENU** *MENU***)** [Function]

Returns the window *MENU* is located in, if it is in one; **NIL** otherwise.

**(DOSELECTEDITEM** *MENU ITEM BUTTON***)** [Function]

Calls *MENU*'s **WHENSELECTEDFN** on *ITEM* and *BUTTON*. It provides a programmatic way of making a selection. It does not change the display.

**(MENUITEMREGION** *ITEM MENU***)** [Function]

Returns the region occupied by *ITEM* in *MENU*.

**(SHADEITEM** *ITEM MENU SHADE DS/W***)** [Function]

Shades the region occupied by *ITEM* in *MENU*. If *DS/W* is a display stream or a window, it is assumed to be where *MENU* is displayed. Otherwise, **WFROMMENU** is called to locate the window *MENU* is in. Shading is persistent, and is reapplied when the window the menu is in gets redisplayed. To unshade an item, call with a *SHADE* of 0.

**(PUTMENUPROP** *MENU PROPERTY VALUE***)** [Function]

Stores the property *PROPERTY* with the value *VALUE* on a property list in the menu *MENU*. The user can use this property list for associating arbitrary data with a menu object.

**(GETMENUPROP** *MENU PROPERTY***)** [Function]

Returns the value of the *PROPERTY* property of the menu *MENU*.

## 28.5.3 Examples of Menu Use

Example: A simple menu:

**(MENU (create MENU ITEMS ← '((YES T) (NO (QUOTE NIL))) ))**

Creates a menu with items **YES** and **NO** in a single vertical column:


If **YES** is selected, **T** will be returned. Otherwise, **NIL** will be returned.

Example: A simple menu, with centering:

```
(MENU (create MENU TITLE ← "Foo?"
      ITEMS ← '((YES T "Adds the Foo feature.")
               (NO 'NO "Removes the Foo feature."))
      CENTERFLG ← T))
```

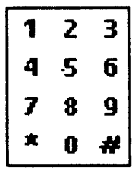
Creates a menu with a title **Foo?** and items **YES** and **NO** centered in a single vertical column:

The strings following the **YES** and **NO** are help strings and will be printed if the cursor remains over one of the items for a period of time. This menu differs from the one above in that it distinquishes the **NO** case from the case where the user clicked outside of the menu. If the user clicks outside of the menu, **NIL** is returned.

Example: A multi-column menu:

```
(create MENU ITEMS ← '(1 2 3 4 5 6 7 8 9 * 0 #)
      CENTERFLG ← T
      MENUCOLUMNS ← 3
      MENUFONT ← (FONTCREATE 'MODERN 10 'BOLD)
      ITEMHEIGHT ← 15
      ITEMWIDTH ← 15
      CHANGEOFFSETFLG ← T)
```

Creates a touch-tone-phone number pad with the items in 15 by 15 boxes printed in Modern 10 bold font:




If used in pop up mode, its first use will have the cursor in the middle. Subsequent use will have the cursor in the same relative location as the previous selection.

Example: A program using a previously-saved menu:

```
(SELECTQ [MENU
     (COND ((type? MENU FOOMENU)
          (* use previously computed menu.)
          FOOMENU)
        (T (* create and save the menu)
          (SETQ FOOMENU
            (create MENU
              ITEMS ← '((A 'A-SELECTED "prompt string for A")
                   (B 'B-SELECTED "prompt string for B"]
     (A-SELECTED (* if A is selected) (DOATHING))
     (B-SELECTED (* if B is selected) (DOBTHING))
     (PROGN (* user selected outside the menu) NIL)))
```

This expression displays a pop up menu with two items, **A** and **B**, and waits for the user to select one. If **A** is selected, **DOATHING** is called. If **B** is selected, **DOBTHING** is called. If neither of these is selected, the form returns **NIL**.

The purpose of this example is to show some good practices to follow when using menus. First, the menu is only created once, and saved in the variable **FOOMENU**. This is more efficient if the menu is used more than once. Second, all of the information about the menu is kept in one place, which makes it easy to understand and edit. Third, the forms evaluated as a result of selecting something from the menu are part of the code and hence will be known to masterscope (as opposed to the situation if the forms were stored as part of the items). Fourth, the items in the menu have help strings for the user. Finally, the code is commented (always worth the trouble).

## 28.6 Attached Windows

The attached window facility makes it easy to manipulate a group of window as a unit. Standard window operations like moving, reshaping, opening, and closing can be done so that it appears to the user as if the windows are a single entity. Each collection of attached windows has one main window and any number of other windows that are "attached" to it. Moving or reshaping the main window causes all of the attached windows to be moved or reshaped as well. Moving or reshaping an attached window does not affect the main window.

Attached windows can have other windows attached to them. Thus, it is possible to attach window A to window B when B is already attached to window C. Similarly, if A has other windows attached to it, it can still be attached to B.

**(ATTACHWINDOW** *WINDOWTOATTACH MAINWINDOW EDGE POSITIONONEDGE WINDOWCOMACTION***)** [Function]

Associates *WINDOWTOATTACH* with *MAINWINDOW* so that window operations done to *MAINWINDOW* are also done to *WINDOWTOATTACH* (the exact set of window operations passed between main windows and attached windows is described on page 28.51). **ATTACHWINDOW** moves *WINDOWTOATTACH* to the correct position relative to *MAINWINDOW*.

Note: A window can be attached to only one other window. Attaching a window to a second window will detach it from the first. Attachments can not form loops. That is, a window cannot be attached to itself or to a window that is attached to it. **ATTACHWINDOW** will generate an error if this is attempted.

*EDGE* determines which edge of *MAINWINDOW* the attached window is positioned along: it should be one of **TOP**, **BOTTOM**, **LEFT**, or **RIGHT**. If *EDGE* is **NIL**, it defaults to **TOP**.

*POSITIONONEDGE* determines where along *EDGE* the attached window is positioned. It should be one of the following:

**LEFT** The attached window is placed on the left (of a **TOP** or **BOTTOM** edge).

**RIGHT** The attached window is placed on the right (of a **TOP** or **BOTTOM** edge).

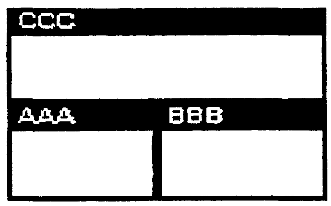
**BOTTOM** The attached window is placed on the bottom (of a **LEFT** or **RIGHT** edge).

**TOP** The attached window is placed on the top (of a **LEFT** or **RIGHT** edge).

**CENTER** The attached window is placed in the center of the edge.

**JUSTIFY or NIL** The attached window is placed to fill the entire edge. **ATTACHWINDOW** reshapes the window if necessary.

Note: The width or height used to justify an attached window includes any other windows that have already been attached to *MAINWINDOW*. Thus **(ATTACHWINDOW BBB AAA 'RIGHT 'JUSTIFY)** followed by **(ATTACHWINDOW CCC AAA 'TOP 'JUSTIFY)** will put **CCC** across the top of both **BBB** and AAA:




*WINDOWCOMACTION* provides a convenient way of specifying how *WINDOWTOATTACH* responds to right button menu commands. The window property **PASSTOMAINCOMS** determines which right button menu commands are directly applied to the attached window, and which are passed to the main window (see page 28.51). Depending on the value of *WINDOWCOMACTION*, the **PASSTOMAINCOMS** window property of *WINDOWTOATTACH* is set as follows:

**NIL** **PASSTOMAINCOMS** is set to **(CLOSEW MOVEW SHAPEW SHRINKW BURYW)**, so right button menu commands to close, move, shape, shrink, and bury are passed to the main window, and all others are applied to the attached window.

**LOCALCLOSE** **PASSTOMAINCOMS** is set to **(MOVEW SHAPEW SHRINKW BURYW)**, which is the same as when *WINDOWCOMACTION* is **NIL**, except that the attached window can be closed independently.

**HERE** **PASSTOMAINCOMS** is set to **NIL**, so all right button menu commands are applied to the attached window.

**MAIN** **PASSTOMAINCOMS** is set to **T**, so all right button menu commands are passed to the main window.

Note: If the user wants to set the **PASSTOMAINCOMS** window property of an attached window to something else, it must be done *after* the window is attached, since **ATTACHWINDOW** modifies this window property.

**(DETACHWINDOW** *WINDOWTODETACH***)** [Function]

Detaches *WINDOWTODETACH* from its main window. Returns a dotted pair (*EDGE . POSITIONONEDGE*) if *WINDOWTODETACH* was an attached window, **NIL** otherwise. This does not close *WINDOWTODETACH*.

**(DETACHALLWINDOWS** *MAINWINDOW***)** [Function]

Detaches and closes all windows attached to *MAINWINDOW*.

**(FREEATTACHEDWINDOW** *WINDOW***)** [Function]

Detaches the attached window *WINDOW*. In addition, other attached windows above (in the case of a **TOP** attached window) or below (in the case of a **BOTTOM** attached window) are moved closer to the main window to fill the gap.

Note: Attached windows that "reject" the move operation (see **REJECTMAINCOMS**, page 28.51) are not moved.

Note: **FREEATTACHEDWINDOW** currently doesn't handle **LEFT** or **RIGHT** attached windows.

**(REMOVEWINDOW** *WINDOW***)** [Function]

Closes *WINDOW*, and calls **FREEATTACHEDWINDOW** to move other attached windows to fill any gaps.

**(REPOSITIONATTACHEDWINDOWS** *WINDOW***)** [Function]

Repositions every window attached to *WINDOW*, in the order that they were attached. This is useful as a **RESHAPEFN** for main windows with attached window that don't want to be reshaped, but do want to keep their position relative to the main window when the main window is reshaped.

Note: Attached windows that "reject" the move operation (see **REJECTMAINCOMS**, page 28.51) are not moved.

**(MAINWINDOW** *WINDOW RECURSEFLG***)** [Function]

If *WINDOW* is not a window, it generates an error. If *WINDOW* is closed, it returns *WINDOW*. If *WINDOW* is not attached to another window, it returns *WINDOW* itself. If *RECURSEFLG* is **NIL** and *WINDOW* is attached to a window, it returns that window. If *RECURSEFLG* is **T**, it returns the first window up the "main window" chain starting at *WINDOW* that is not attached to any other window.

**(ATTACHEDWINDOWS** *WINDOW COM***)** [Function]

Returns the list of windows attached to *WINDOW*.

If *COM* is non-**NIL**, only those windows attached to *WINDOW* that do not reject the window operation *COM* are returned (see **REJECTMAINCOMS**, page 28.51).

**(ALLATTACHEDWINDOWS** *WINDOW***)** [Function]

Returns a list of all of the windows attached to *WINDOW* or attached to a window attached to it.

**(WINDOWREGION** *WINDOW COM***)** [Function]

Returns the screen region occupied by *WINDOW* and its attached windows, if it has any.

If *COM* is non-**NIL**, only those windows attached to *WINDOW* that do not reject the window operation *COM* are considered in the calculation (see **REJECTMAINCOMS**, page 28.51).

**(WINDOWSIZE** *WINDOW***)** [Function]

Returns the size of *WINDOW* and its attached windows (if any), as a dotted pair **(***WIDTH* . *HEIGHT***)**.

**(MINATTACHEDWINDOWEXTENT** *WINDOW***)** [Function]

Returns the minimum size that *WINDOW* and its attached windows (if any) will accept, as a dotted pair **(***WIDTH* . *HEIGHT***)**.

## 28.6.1 Attaching Menus To Windows

The following functions are provided to associate menus to windows.

**(MENUWINDOW** *MENU VERTFLG***)** [Function]

Returns a closed window that has the menu *MENU* in it. If *MENU* is a list, a menu is created with *MENU* as its **ITEMS** menu field (see page 28.39). Otherwise, *MENU* should be a menu. The returned window has the appropriate **RESHAPEFN**, **MINSIZE** and **MAXSIZE** window properties to allow its use in a window group.

If both the **MENUROWS** and **MENUCOLUMNS** fields of *MENU* are **NIL**, *VERTFLG* is used to set the default menu shape. If *VERTFLG* is non-**NIL**, the **MENUCOLUMNS** field of *MENU* will be set to 1 (the menu items will be listed vertically); otherwise the **MENUROWS** field of *MENU* will be set to 1 (the menu items will be listed horizontally).

**(ATTACHMENU** *MENU MAINWINDOW EDGE POSITIONONEDGE NOOPENFLG***)** [Function]

Creates a window that contains the menu *MENU* (by calling **MENUWINDOW**) and attaches it to the window *MAINWINDOW* on edge *EDGE* at position *POSITIONONEDGE*. The menu window is opened unless *MAINWINDOW* is closed, or *NOOPENFLG* is **T**.

If *EDGE* is either **LEFT** or **RIGHT**, **MENUWINDOW** will be called with *VERTFLG* = **T**, so the menu items will be listed vertically; otherwise the menu items will be listed horizontally. These defaults can be overridden by specifying the **MENUROWS** or **MENUCOLUMNS** fields in *MENU*.

**(CREATEMENUEDWINDOW** *MENU WINDOWTITLE LOCATION WINDOWSPEC***)** [Function]

Creates a window with an attached menu and returns the main window. *MENU* is the only required argument, and may be a menu or a list of menu items. *WINDOWTITLE* is a string specifying the title of the main window. *LOCATION* specifies the edge on which to place the menu; the default is **TOP**. *WINDOWSPEC* is a region specifying a region for the aggregate window; if **NIL**, the user is prompted for a region.

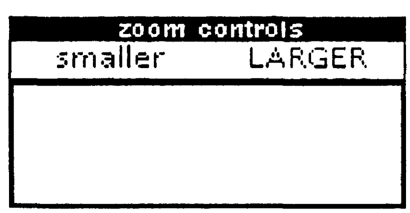
Examples:

```
(SETQ MENUW
 (MENUWINDOW
  (create MENU
   ITEMS ← '(smaller LARGER)
   MENUFONT ← '(MODERN 12)
   TITLE ← "zoom controls"
   CENTERFLG ← T
   WHENSELECTEDFN ← (FUNCTION ZOOMMAINWINDOW))))
```

creates (but does not open) a menu window that contains the two items "**smaller**" and "**LARGER**" with the title "**zoom controls**" and that calls the function **ZOOMMAINWINDOW** when an item is selected. Note that the menu items will be listed horizontally, because **MENUWINDOW** is called with *VERTFLG* = **NIL**, and the menu does not specify either a **MENUROWS** or **MENUCOLUMNS** field.

```
(ATTACHWINDOW MENUW
 (CREATEW '(50 50 150 50))
 'TOP
 'JUSTIFY)
```

creates a window on the screen and attaches the above created menu window to its top:




**(CREATEMENUEDWINDOW**

```
(create MENU
  ITEMS ← '(smaller LARGER)
  MENUFONT ← '(MODERN 12)
  TITLE ← "zoom controls"
  CENTERFLG ← T
  WHENSELECTEDFN ← (FUNCTION ZOOMMAINWINDOW))))
```

creates the same sort of window in one step, prompting the user for a region.

## 28.6.2 Attached Prompt Windows

Many packages have a need to display status information or prompt for small amounts of user input in a place outside their standard window. A convenient way to do this is to attach a small window to the top of the program's main window. The following functions do so in a uniform way that can be depended on among diverse applications.

**(GETPROMPTWINDOW** *MAINWINDOW #LINES FONT DONTCREATE***)** [Function]

Returns the attached prompt window associated with *MAINWINDOW*, creating it if necessary. The window is always attached to the top of *MAINWINDOW*, has **DSPSCROLL** set to **T**, and has a **PAGEFULLFN** of **NILL** to inhibit page holding. The window is at least *#LINES* lines high (default 1); if a pre-existing window is shorter than that, it is reshaped to make it large enough. *FONT* is the font to give the prompt window (defaults to the font of *MAINWINDOW*), and applies only when the window is first created. If *DONTCREATE* is true, returns the window if it exists, otherwise **NIL** without creating any prompt window.

**(REMOVEPROMPTWINDOW** *MAINWINDOW***)** [Function]

Detaches the attached prompt window associated with *MAINWINDOW* (if any), and closes it.

## 28.6.3 Window Operations And Attached Windows

When a window operation, such as moving or clearing, is performed on a window, there is a question about whether or not that operation should also be performed on the windows attached to it or performed on the window it is attached to. The "right" thing to do depends on the window operation: it makes sense to independently redisplay a single window in a collection of windows, whereas moving a single window usually implies moving the whole group of windows. The interpretation of window operations also depends on the application that the window group is used for. For some applications, it may be desirable to have a window group where individual windows can be moved away from the group, but still be conceptually attached to the group for other operations. The attached window facility is flexible enough to allow all of these possibilities.

The operation of window operations can be specified by each attached window, by setting the following two window properties:

**PASSTOMAINCOMS** [Window Property]

Value is a list of window commands (e.g. **CLOSEW, MOVEW**) which, when selected from the attached window's right-button menu, are actually applied to the central window in the group, instead of being applied to the attached window itself. The "central window" is the first window up the "main window" chain that is not attached to any other window.

If **PASSTOMAINCOMS** is **NIL**, all window operations are directly applied to the attached window. If **PASSTOMAINCOMS** is **T**, all window operations are passed to the central window.

Note: **ATTACHWINDOW** (page 28.45) allows this window property to be set to commonly-used values by using its *WINDOWCOMACTION* argument. **ATTACHWINDOW** always sets this window property, so users must modify it directly only *after* attaching the window to another window.

**REJECTMAINCOMS** [Window Property]

Value is a list of window commands that the attached window will not allow the main window to apply to it. This is how a window can say "leave me out of this group operation."

If **REJECTMAINCOMS** is **NIL**, all window commands may be applied to this attached window. If **REJECTMAINCOMS** is **T**, no window commands may be applied to this attached window.

Note: The **PASSTOMAINCOMS** and **REJECTMAINCOMS** window properties affect right-button menu operations applied to main windows or attached windows, and the action of programmatic window functions (**SHAPEW, MOVEW**, etc.) applied to main windows. However, these window properties do *not* affect the action of window functions applied to attached windows.

The following list describes the behavior of main and attached windows under the window operations, assuming that all attached windows have their **REJECTMAINCOMS** window property set to **NIL** and **PASSTOMAINCOMS** set to **(CLOSEW MOVEW SHAPEW SHRINKW BURYW)** (the default if

**ATTACHWINDOW** is called with *WINDOWCOMACTION* = **NIL**, see page 28.45).

The behavior for any particular operation can be changed for particular attached windows by setting the standard window properties (e.g., **MOVEFN** or **CLOSEFN**) of the attached window. An exception is the **TOTOPFN** property of an attached window, that is set to bring the whole window group to the top and should not be set by the user (although users can *add* functions to the **TOTOPFN** window property).

Move — If the main window moves, all attached windows move with it, and the relative positioning between the main window and the attached windows is maintained. If the region is determined interactively, the prompt region for the move is the union of the extent of the main window and all attached windows (excluding those with **MOVEW** in their **REJECTMAINCOMS** window property).

If an attached window is moved by calling the function **MOVEW**, it is moved without affecting the main window. If the right-button window menu command **Move** is called on an attached window, it is passed on to the main window, so that all windows in the group move.

Reshape — If the main window is reshaped, the minimum size of it and all of its attached windows is used as the minimum of the space for the result. Any space greater than the minimum is distributed among the main window and its attached windows. Attached windows with **SHAPEW** on their **REJECTMAINCOMS** window property are ignored when finding the minimum size, creating a "ghost" region, or distributing space after a reshape.

If an attached window is reshaped by calling the function **SHAPEW**, it is reshaped independently. If the right-button window menu command **Shape** is called on an attached window, it is passed on to the main window, so the whole group is reshaped.

Note: Reshaping the main window will restore the conditions established by the call to **ATTACHWINDOW**, whereas moving the main window does not. Thus, if **A** is attached to the top of **B** and then moved by the user, its new position relative to **B** will be maintained if **B** is moved. If **B** is reshaped, **A** will be reshaped to the top of **B**. Additionally, if, while **A** is moved away from the top of **B**, **C** is attached to the top of **B**, **C** will position itself above where **A** used to be.

Close — If the main window is closed, all of the attached windows are closed also and the links from the attached windows to the main window are broken. This is necessary for the windows to be garbage collected.

If an attached window is closed by calling the function **CLOSEW**, it is closed without affecting the main window. If the right-button window menu command **Close** is called on an attached window, it is passed on to the main window. Note that closing an attached window detaches it.

Open — If the main window is opened, it opens all attached windows and reestablishes links from them to the main window.

Attached windows can be opened independently and this does not affect the main window. Note that it is possible to reopen a closed attached window and not have it linked to its main window.

Shrink — The collection of windows shrinks as a group. The **SHRINKFN**s of the attached windows are evaluated but the only icon displayed is the one for the main window.

Redisplay — The main or attached windows can be redisplayed independently.

Totop — If any main or attached window is brought to the top, all of the other windows are brought to the top also.

Expand — Expanding any of the windows expands the whole collection.

Scrolling — All of the windows involved in the group scroll independently.

Clear — All windows clear independently of each other.

## 28.6.4 Window Properties Of Attached Windows

Windows that are involved in a collection either as a main window or as an attached window have properties stored on them. The only properties that are intended to be set be set by the user are the **MINSIZE**, **MAXSIZE**, **PASSTOMAINCOMS**, and **REJECTMAINCOMS** window properties. The other properties should be considered read only.

**MINSIZE** [Window Property]

**MAXSIZE** [Window Property]

Each of these window properties should be a dotted pair (*WIDTH . HEIGHT*) or a function to apply to the window that returns a dotted pair. The numbers are used when the main window is reshaped. The **MINSIZE** is used to determine the size of the smallest region acceptable during reshaping. Any amount greater than the collective minimum is spread evenly among the windows until each reaches **MAXSIZE**. Any excess is given to the main window.

Note: If you give the main window of an attached window group a **MINSIZE** or **MAXSIZE** property, its value is moved to the

**MAINWINDOWMINSIZE** or **MAINWINDOWMAXSIZE** property, so that the main window can be given a size function that computes the minimum or maximum size of the entire group. Thus, if you want to change the main window's minimum or maximum size after attaching windows to it, you should change the **MAINWINDOWMINSIZE** or **MAINWINDOWMAXSIZE** property instead.

Note: This doesn't address the hard problem of overlapping attached windows side to side, for example if window **A** was attached as [**TOP**, **LEFT**] and **B** as [**TOP**, **RIGHT**]. Currently, the attached window functions do not worry about the overlap.

The default **MAXSIZE** is **NIL**, which will let the region grow indefinitely.

**MAINWINDOW** [Window Property]

Pointer from attached windows to the main window of the group. This link is not available if the main window is closed. The function **MAINWINDOW** (page 28.47) is the preferred way to access this property.

**ATTACHEDWINDOWS** [Window Property]

Pointer from a window to its attached windows. The function **ATTACHEDWINDOWS** (page 28.47) is the preferred way to access this property.

**WHEREATTACHED** [Window Property]

For attached windows, a dotted pair (*EDGE . POSITIONONEDGE*) giving the edge and position on the edge that determine how the attached window is placed relative to its main window.

The **TOTOPFN** window property on attached windows and the properties **TOTOPFN, DOSHAPEFN, MOVEFN, CLOSEFN, OPENFN, SHRINKFN, EXPANDFN** and **CALCULATEREGIONFN** on main windows contain functions that implement the attached window manipulation facilities. Care should be used in modifying or replacing these properties.

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# 29. HARDCOPY FACILITIES

Interlisp-D includes facilities for generating hardcopy in "Interpress" format and "Press" format. Interpress is a file format used for communicating documents to Xerox Network System printers such as the Xerox 8044 and Xerox 5700. Press is a file format used for communicating documents to Xerox laser Xerographic printers known by the names "Dover", "Spruce", "Penguin", and "Raven". There are also library packages available for supporting other types of printer formats (4045, FX-80, C150, etc.). The hardcopy facilities are designed to allow the user to support new types of printers with minimal changes to the user interface.

Files can be in a number of formats, including Interpress files, plain text files, and formatted Tedit files. In order to print a file on a given printer, it is necessary to identify the format of the file, convert the file to a format that the printer can accept, and transmit it. Rather than require that the user explicitly determine file types and do the conversion, the Interlisp-D hardcopy functions generate Interpress or other format output depending on the appropriate choice for the designated printer. The hardcopy functions use the variables **PRINTERTYPES** and **PRINTFILETYPES** (described below) to determine the type of a file, how to convert it for a given printer, and how to send it. By changing these variables, the user can define other kinds of printers and print to them using the normal hardcopy functions.

**(SEND.FILE.TO.PRINTER** *FILE HOST PRINTOPTIONS***)** [Function]

The function **SEND.FILE.TO.PRINTER** causes the file *FILE* to be sent to the printer *HOST*. If *HOST* is **NIL**, the first host in the list **DEFAULTPRINTINGHOST** which can print *FILE* is used.

*PRINTOPTIONS* is a property list of the form (*PROP1 VALUE1 PROP2 VALUE2* ...). The properties accepted depends on the type of printer. For Interpress printers, the following properties are accepted:

**DOCUMENT.NAME** The document name to appear on the header page (a string). Default is the full name of the file.

**DOCUMENT.CREATION.DATE** The creation date to appear on the header page (a Lisp integer date, such as returned by **IDATE**). The default value is the creation date of the file.

**SENDER.NAME** The name of the sender to appear on the header page (a string). The default value is the name of the user.

**RECIPIENT.NAME** The name of the recipient to appear on the header page (a string). The default is none.

**MESSAGE** An additional message to appear on the header page (a string). The default is none.

**#COPIES** The number of copies to be printed. The default value is 1.

**PAGES.TO.PRINT** The pages of the document that should be printed, represented as a list (*FIRSTPAGE# LASTPAGE#*). For example, if this option is **(3 5)**, this specifies that pages 3 through 5, inclusive, should be printed. Note that the page numbering used for this purpose has no connection to any page numbers that may be printed on the document. The default is to print all of the pages in the document.

**MEDIUM** The medium on which the master is to be printed. If omitted, this defaults to the value of **NSPRINT.DEFAULT.MEDIUM**, as follows: **NIL** means to use the printer's default; **T** means to use the first medium reported available by the printer; any other value must be a Courier value of type **MEDIUM**. The format of this type is a list **(PAPER (KNOWN.SIZE** *TYPE***))** or **(PAPER (OTHER.SIZE (***WIDTH LENGTH***)))**. The paper *TYPE* is one of **US.LETTER, US.LEGAL, A0** through **A10, ISO.B0** through **ISO.B10**, and **JIS.B0** through **JIS.B10**. For users who use A4 paper exclusively, it should be sufficient to set **NSPRINT.DEFAULT.MEDIUM** to **(PAPER (KNOWN.SIZE "A4"))**.

When using different paper sizes, it may be necessary to reset the variable **DEFAULTPAGEREGION**, the region on the page used for printing (measured in micas from the lower-left corner).

**STAPLE?** True if the document should be stapled.

**#SIDES** 1 or 2 to indicate that the document should be printed on one or two sides, respectively. The default is the value of **EMPRESS#SIDES**.

**PRIORITY** The priority of this print request, one of **LOW**, **NORMAL**, or **HIGH**. The default is the printer's default.

Note: Press printers only recognize the options **#COPIES**, **#SIDES**, **DOCUMENT.CREATION.DATE**, and **DOCUMENT.NAME**.

For example,

```
(SEND.FILE.TO.PRINTER 'FOO NIL
  '(#COPIES 3 #SIDES 2 DOCUMENT.NAME "For John"))
```

**SEND.FILE.TO.PRINTER** calls **PRINTERTYPE** and **PRINTFILETYPE** to determine the printer type of *HOST* and the file format of *FILE*. If *FILE* is a formatted file already in a form that the printer can print, it is transmitted directly. Otherwise, **CONVERT.FILE.TO.TYPE.FOR.PRINTER** is called to do the conversion. [Note: If the file is converted, *PRINTOPTIONS* is passed to the formatting function, so it can include properties such as **HEADING, REGION**, and **FONTS**.] All of these functions use the lists **PRINTERTYPES** and **PRINTFILETYPES** to actually determine how to do the conversion.

**LISTFILES** (page 17.14) calls the function **LISTFILES1** to send a single file to a hardcopy printing device. Interlisp-D is initialized with **LISTFILES1** defined to call **SEND.FILE.TO.PRINTER**.

**(HARDCOPYW** *WINDOW/BITMAP/REGION FILE HOST SCALEFACTOR ROTATION PRINTERTYPE***)** [Function]

Creates a hardcopy file from a bitmap and optionally sends it to a printer. Note that some printers may have limitations concerning how big or how "complicated" the bitmap may be printed.

*WINDOW/BITMAP/REGION* can either be a **WINDOW** (open or closed), a **BITMAP**, or a **REGION** (interpreted as a region of the screen). If *WINDOW/BITMAP/REGION* is **NIL**, the user is prompted for a screen region using **GETREGION**.

If *FILE* is non-**NIL**, it is used as the name of the file for output. If *HOST* = **NIL**, this file is not printed. If *FILE* is **NIL**, a temporary file is created, and sent to *HOST*.

To save an image on a file without printing it, perform **(HARDCOPYW** *IMAGE FILE***)**. To print an image to the printer *PRINTER* without saving the file, perform **(HARDCOPYW** *IMAGE* **NIL** *PRINTER***)**.

If both *FILE* and *HOST* are **NIL**, the default action is to print the image, without saving the file. The printer used is determined by the argument *PRINTERTYPE* and the value of the variable **DEFAULTPRINTINGHOST**. If *PRINTERTYPE* is non-**NIL**, the first host on **DEFAULTPRINTINGHOST** of the type *PRINTERTYPE* is used. If *PRINTERTYPE* is **NIL**, the first printer on **DEFAULTPRINTINGHOST** that implements the **BITMAPSCALE** (as determined by **PRINTERTYPES**, page 29.5) operation is used, if any. Otherwise, the first printer on **DEFAULTPRINTINGHOST** is used.

The type of hardcopy file produced is determined by *HOST* if non-**NIL**, else by *PRINTERTYPE* if non-**NIL**, else by the value of **DEFAULTPRINTINGHOST**, as described above.

*SCALEFACTOR* is a reduction factor. If not given, it is computed automatically based on the size of the bitmap and the capabilities of the printer type. This may not be supported for some printers.

*ROTATION* specifies how the bitmap image should be rotated on the printed page. Most printers (including Interpress printers) only support a *ROTATION* of multiples of 90.

*PRINTERTYPE* specifies what type of printer to use when *HOST* is **NIL**. **HARDCOPYW** uses this information to select which printer to use or what print file format to convert the output into, as described above.

The background menu contains a "Hardcopy" command (page 28.6) that prompts the user for a region on the screen, and sends the image to the default printer.

Hardcopy output may also be obtained by writing a file on the printer device **LPT**, e.g. **(COPYFILE 'FOO '{LPT})**. When a file on this device is closed, it is converted to Interpress or some other format (if necessary) and sent to the default printer (the first host on *DEFAULTPRINTINGHOST*). One can include the printer name directly in the file name, e.g. **(COPYFILE 'FOO {LPT}TREMOR:)** will send the file to the printer **TREMOR:**.

**(PRINTERSTATUS** ***PRINTER*****)** [Function]

Returns a list describing the current status of the printer named *PRINTER*. The exact form of the value returned depends on the type of printer. For Interpress printers, the status describes whether the printer is available or busy or needs attention, and what type of paper is loaded in the printer.

Returns **NIL** if the printer does not respond in a reasonable time, which can occur if the printer is very busy, or does not implement the printer status service.

**DEFAULTPRINTINGHOST** [Variable]

The variable **DEFAULTPRINTINGHOST** is used to designate the default printer to be used as the output of printing operations. It should be a list of the known printer host names, for example, **(QUAKE LISPPRINT:)**. If an element of **DEFAULTPRINTINGHOST** is a list, is interpreted as **(***PRINTERTYPE HOST***)**, specifying both the host type and the host name. The type of the printer, which determines the protocol used to send to it and the file format it requires, is determined by the function **PRINTERTYPE**.

If **DEFAULTPRINTINGHOST** is a single printer name, it is treated as if it were a list of one element.

**(PRINTFILETYPE** ***FILE* —)** [Function]

Returns the format of the file *FILE*. Possible values include **INTERPRESS**, **TEDIT**, etc. If it cannot determine the file type, it returns **NIL**. Uses the global variable **PRINTFILETYPES**.

**(PRINTERTYPE** ***HOST*****)** [Function]

Returns the type of the printer *HOST*. Currently uses the following heuristic: (1) If *HOST* is a list, the **CAR** is assumed to be the printer type and **CADR** the name of the printer; (2) If *HOST* is a litatom with a non-**NIL** **PRINTERTYPE** property, the property value is returned as the printer type; (3) If *HOST* contains a colon (e.g., **PRINTER:PARC:XEROX**) it is assumed to be an **INTERPRESS** printer; (4) if *HOST* is the **CADR** of a list on **DEFAULTPRINTINGHOST**, the **CAR** is returned as the printer type; (5) otherwise, the value of **DEFAULTPRINTERTYPE** is returned as the printer type.

## 29.1 Low-level Hardcopy Variables

The following variables are used to define how Interlisp should generate hardcopy of different types. The user should only need to change these variables when it is necessary to access a new type of printer, or define a new hardcopy document type (not often).

**PRINTERTYPES** [Variable]

The characteristics of a given printer are determined by the value of the list **PRINTERTYPES**. Each element is a list of the form

**(***TYPES* **(***PROPERTY1 VALUE1***)** **(***PROPERTY2 VALUE2***)** ...**)**

*TYPES* is a list of the printer types that this entry addresses. The **(***PROPERTYn VALUEn***)** pairs define properties associated with each printer type.

The printer properties include the following:

**CANPRINT** Value is a list of the file types that the printer can print directly.

**STATUS** Value is a function that knows how to find out the status of the printer, used by **PRINTERSTATUS** (page 29.4).

**PROPERTIES** Value is a function which returns a list of known printer properties.

**SEND** Value is a function which invokes the appropriate protocol to send a file to the printer.

**BITMAPSCALE** Value is a function of arguments *WIDTH* and *HEIGHT* in bits which returns a scale factor for scaling a bitmap.

**BITMAPFILE** Value is a form which, when evaluated, converts a bitmap to a file format that the printer will accept.

Note: The name **8044** is defined on **PRINTERTYPES** as a synonym for the **INTERPRESS** printer type. The names **SPRUCE**, **PENGUIN**, and **DOVER** are defined on **PRINTERTYPES** as synonyms for the **PRESS** printer type. The printer types **FULLPRESS** and **RAVEN** are also defined the same as **PRESS**, except that these printer types indicate that the printer is a "Full Press" printer that is able to scale bitmap images, in addition to the normal Press printer facilities.

**PRINTFILETYPES** [Variable]

The variable **PRINTFILETYPES** contains information about various file formats, such as Tedit files and Interpress files. The format is similar to **PRINTERTYPES**. The properties that can be specified include:

**TEST** Value is a function which tests a file if it is of the given type. Note that this function is passed an open stream.

**CONVERSION** Value is a property list of other file types and funcitons that convert from the specified type to the file format.

**EXTENSION** Value is a list of possible file extensions for files of this type.

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# 30. TERMINAL INPUT/OUTPUT

Most input/output operations in Interlisp can be simply modeled as reading or writing on a linear stream of bytes. However, the situation is much more complex when it comes to controlling the user's "terminal," which includes the keyboard, the mouse, and the display screen. For example, Interlisp coordinates the operation of these separate I/O devices so that the cursor on the screen moves as the mouse moves, and any characters typed by the user appear in the window currently containing a flashing cursor. Most of the time, this system works correctly without need for user modification.

The purpose of this chapter is to describe how to access the low-level controls for the terminal I/O devices. It documents the use of interrupt characters, the keyboard characters that generate interrupts. Then, it describes terminal tables, used to determine the meaning of the different editing characters (character delete, line delete, etc.). Then, the "dribble file" facility that allows terminal I/O to be saved onto a file is presented (page 30.12). Finally, the low-level functions that control the mouse and cursor, the keyboard, and the screen are documented.

## 30.1 Interrupt Characters

Errors and breaks can be caused by errors within functions, or by explicitly breaking a function. The user can also indicate his desire to go into a break while a program is running by typing certain control characters known as "interrupt characters". The following interrupt characters are currently enabled in Interlisp-D:

Note: In Interlisp-D with multiple processes, it is not sufficient to say that "the computation" is broken, aborted, etc; it is necessary to specify which process is being acted upon. Usually, the user wants interrupts to occur in the TTY process, which is the one currently receiving keyboard input. However, sometimes the user wants to interrupt the mouse process, if it is currently busy executing a menu command or waiting for the user to specify a region on the screen. Most of the interrupt characters below take place in the mouse process if it is busy, otherwise the

TTY process. Control-G can be used to break arbitrary processes. For more information, see page 23.14.

Control-B Causes a break within the mouse process (if busy) or the TTY process. Use control-G to break a particular process.

Control-D Aborts the mouse process (if busy) or the TTY process, and unwinds its stack to the top level. Calls **RESET** (page 14.20).

Control-E Aborts the mouse process (if busy) or the TTY process, and unwinds its stack to the last **ERRORSET**. Calls **ERROR!** (page 14.20).

Control-G Pops up a menu listing all of the currently-running processes. Selecting one of the processes will cause a break to take place in that process.

Control-P Changes the **PRINTLEVEL** setting of **PRINTLEVEL** (see page 25.11) in the TTY process. This allows the **PRINTLEVEL** setting to be changed dynamically, even while Interlisp is printing.

When control-P is typed, Interlisp rings the bell, prints "**set printlevel to:**," and waits for the user to type a series of digits. Input is terminated by a non-digit, after which the program continues.

If the input is terminated by a period or an exclamation point, the **CAR** printlevel is immediately set to this number, and printing continues with the (possibly new) printlevel. If the print routine is currently deeper than the new level, all unfinished lists above that level will be terminated by "--)". Thus, if a circular or long list of atoms, is being printed out, typing "control-P0." will cause the list to be terminated immediately.

If the input is terminated by a comma, another number may be typed terminated by a period or exclamation point. The **CAR** printlevel will then be set to the first number, the **CDR** printlevel to the second number.

In either case, if a period is used to terminate the printlevel setting, the printlevel will be returned to its previous setting after the current printout has finished. If an exclamation point is used, the change is permanent and the printlevel is not restored (until it is changed again).

Control-T Prints status information for the TTY process. First it prints "IO wait," "Waiting", or "Running," depending on whether the TTY process is currently in waiting for characters to be typed, waiting for some other reason, or running. Next, it prints the names of the top three frames on the stack, to show what is running. Then, it prints a line describing the percentage of time (since the last control-T) that has been spent running a program, swapping, garbage collecting, doing local disk i/o, etc. For example:

**Running in TTWAITFORINPUT in TTBIN in TTYIN1**
**95% Util, 0% Swap, 4% GC**

DELETE Clears typeahead in all processes.

The user can disable and/or redefine Interlisp interrupt characters, as well as define new interrupt characters. Interlisp-D is initialized with the following interrupt channels: **RESET** (control-D), **ERROR** (control-E), **BREAK** (control-B), **HELP** (control-G), **PRINTLEVEL** (control-P), **RUBOUT** (DELETE), and **RAID**. Each of these channels independently can be disabled, or have a new interrupt character assigned to it via the function **INTERRUPTCHAR** described below. In addition, the user can enable new interrupt channels, and associate with each channel an interrupt character and an expression to be evaluated when that character is typed.

**(INTERRUPTCHAR** *CHAR TYP/FORM HARDFLG* **—)** [Function]

Defines *CHAR* as an interrupt character. If *CHAR* was previously defined as an interrupt character, that interpretation is disabled.

*CHAR* is either a character or a character code (page 2.12). Note that full sixteen-bit NS characters can be specified as interrupt characters (see page 2.12). *CHAR* can also be a value returned from **INTERRUPTCHAR**, as described below.

If *TYP/FORM* = **NIL**, *CHAR* is disabled.

If *TYP/FORM* = **T**, the current state of *CHAR* is returned without changing or disabling it.

If *TYP/FORM* is one of the literal atoms **RESET**, **ERROR**, **BREAK**, **HELP**, **PRINTLEVEL**, **RUBOUT**, or **RAID**, then **INTERRUPTCHAR** assigns *CHAR* to the indicated Interlisp interrupt channel, (reenabling the channel if previously disabled).

If *TYP/FORM* is any other literal atom, *CHAR* is enabled as an interrupt character that when typed causes the atom *TYP/FORM* to be *immediately* set to **T**.

If *TYP/FORM* is a list, *CHAR* is enabled as a user interrupt character, and *TYP/FORM* is the form that is evaluated when *CHAR* is typed. The interrupt will be hard if *HARDFLG* = **T**, otherwise soft.

**(INTERRUPTCHAR T)** restores all Interlisp channels to their original state, and disables all user interrupts.

*HARDFLG* determines what process the interrupt should run in. If *HARDFLG* is **NIL**, the interrupt will run in the TTY process, which is the process currently receiving keyboard input. If *HARDFLG* is **T**, the interrupt will occur in whichever process happens to be running. If *HARDFLG* is **MOUSE**, the interrupt will happen in the mouse process, if the mouse is busy, otherwise in the TTY process.

**INTERRUPTCHAR** returns a value which, when given as the *CHAR* argument to **INTERRUPTCHAR**, will restore things as they were before the call to **INTERRUPTCHAR**. Therefore, **INTERRUPTCHAR**

can be used in conjunction with **RESETFORM** or **RESETLST** (page 14.26).

**INTERRUPTCHAR** is undoable.

**(RESET.INTERRUPTS** *PERMITTEDINTERRUPTS SAVECURRENT?***)** [Function]

*PERMITTEDINTERRUPTS* is a list of interrupt character settings to be performed, each of the form **(***CHAR TYP/FORM HARDFLG***)**. The effect of **RESET.INTERRUPTS** is as if **(INTERRUPTCHAR** *CHAR TYP/FORM HARDFLG***)** were performed for each item on *PERMITTEDINTERRUPTS*, and **(INTERRUPTCHAR** *OTHERCHAR* **NIL)** were performed on every other existing interrupt character.

If *SAVECURRENT?* is non-**NIL**, then **RESET.INTERRUPTS** returns the current state of the interrupts in a form that could be passed to **RESET.INTERRUPTS**, otherwise it returns **NIL**. This can be used with a **RESET.INTERRUPTS** that appears in a **RESETFORM**, so that the list is built at "entry", but not upon "exit".

**(LISPINTERRUPTS)** [Function]

Returns the initial default interrupt character settings for Interlisp-D, as a list that **RESET.INTERRUPTS** would accept.

**(INTERRUPTABLE** *FLAG***)** [Function]

if *FLAG* = **NIL**, turns interrupts off. If *FLAG* = **T**, turns interrupts on. Value is previous setting. **INTERRUPTABLE** compiles open.

Any interrupt character typed while interrupts are off is treated the same as any other character, i.e. placed in the input buffer, and will not cause an interrupt when interrupts are turned back on.

## 30.2 Terminal Tables

A read table (page 25.33) contains input/output information that is *media-independent*. For example, the action of parentheses is the same regardless of the device from which the input is being performed. A terminal table is an object that contains information that pertains to *terminal* input/output operations only, such as the character to type to delete the last character or to delete the last line. In addition, terminal tables contain such information as how line-buffering is to be performed, how control characters are to be echoed/printed, whether lower case input is to be converted to upper case, etc.

Using the functions below, the user may change, reset, or copy terminal tables, or create a new terminal table and install it as the primary terminal table via **SETTERMTABLE**. However, unlike read tables, terminal tables cannot be passed as arguments to input/output functions.

**(GETTERMTABLE** *TTBL***)** [Function]

If *TTBL* = **NIL**, returns the primary (i.e., current) terminal table. If *TTBL* is a terminal table, return *TTBL*. Otherwise, generates an **ILLEGAL TERMINAL TABLE** error.

**(COPYTERMTABLE** *TTBL***)** [Function]

Returns a copy of *TTBL*. *TTBL* can be a real terminal table, **NIL** (copies the primary terminal table), or **ORIG** (returns a copy of the *original* system terminal table). Note that **COPYTERMTABLE** is the only function that creates a terminal table.

**(SETTERMTABLE** *TTBL***)** [Function]

Sets the primary terminal table to be *TTBL*. Returns the previous primary terminal table. Generates an **ILLEGAL TERMINAL TABLE** error if *TTBL* is not a real terminal table.

**(RESETTERMTABLE** *TTBL FROM***)** [Function]

Copies (smashes) *FROM* into *TTBL*. *FROM* and *TTBL* can be **NIL** or a real terminal table. In addition, *FROM* can be **ORIG**, meaning to use the system's original terminal table.

**(TERMTABLEP** *TTBL***)** [Function]

Returns *TTBL*, if *TTBL* is a real terminal table, **NIL** otherwise.

## 30.2.1 Terminal Syntax Classes

A terminal table associates with each character a single "terminal syntax class", one of **CHARDELETE, LINEDELETE, WORDDELETE, RETYPE, CTRLV, EOL,** and **NONE**. Unlike read table classes, only one character in a particular terminal table can belong to each of the classes (except for the default class **NONE**). When a new character is assigned one of these syntax classes by **SETSYNTAX** (page 25.37), the previous character is disabled (i.e., reassigned the syntax class **NONE**), and the value of **SETSYNTAX** is the code for the previous character of that class, if any, otherwise **NIL**.

The terminal syntax classes are interpreted as follows:

**CHARDELETE** (Initially BackSpace and control-A in Interlisp-D) Typing this character deletes the previous character typed. Repeated use of this character deletes successive characters back to the beginning of the line.

**LINEDELETE** (Initially control-Q in Interlisp-D) Typing this character deletes the whole line; it cannot be used repeatedly.

**WORDDELETE** (Initially control-W in Interlisp-D) Typing this character deletes the previous "word", i.e., sequence of non-separator characters.

**RETYPE** (Initially control-R) Causes the line to be retyped as Interlisp sees it (useful when repeated deletions make it difficult to see what remains).

**CTRLV**
**CNTRLV** (Initially control-V) When followed by **A**, **B**, ... **Z**, inputs the corresponding control character control-A, control-B, ... control-Z. This allows interrupt characters to be input without causing an interrupt.

**EOL** On input from a terminal, the **EOL** character signals to the line buffering routine to pass the input back to the calling function. It also is used to terminate inputs to **READLINE** (page 13.36). In general, whenever the phrase carriage-return linefeed is used, what is meant is the character with terminal syntax class **EOL**.

**NONE** The terminal syntax class of all other characters.

**GETSYNTAX**, **SETSYNTAX**, and **SYNTAXP** all work on terminal tables as well as read tables (see page 25.36). As with read tables, full sixteen-bit NS characters can be specified in terminal tables (see page 2.12). When given **NIL** as a *TABLE* argument, **GETSYNTAX** and **SYNTAXP** use the primary read table or primary terminal table depending on which table contains the indicated *CLASS* argument. For example, **(SETSYNTAX** *CH* **'BREAK)** refers to the primary read table, and **(SETSYNTAX** *CH* **'CHARDELETE)** refers to the primary terminal table. In the absence of such information, all three functions default to the primary read table; e.g., **(SETSYNTAX '{ '%[)** refers to the primary read table. If given incompatible *CLASS* and table arguments, all three functions generate errors. For example, **(SETSYNTAX** *CH* **'BREAK** *TTBL***)**, where *TTBL* is a terminal table, generates an **ILLEGAL READTABLE** error, and **(GETSYNTAX 'CHARDELETE** *RDTBL***)** generates an **ILLEGAL TERMINAL TABLE** error.

## 30.2.2 Terminal Control Functions

**(ECHOCHAR** *CHARCODE MODE TTBL***)** [Function]

**ECHOCHAR** sets the "echo mode" of the character *CHARCODE* to *MODE* in the terminal table *TTBL*. The "echo mode" determines how the character is to be echoed or printed. Note that although the name of this function suggests echoing only, it affects *all* output of the character, both echoing of input and printing of output.

*CHARCODE* should be a character code. *CHARCODE* can also be a list of characters, in which case **ECHOCHAR** is applied to each of them with arguments *MODE* and *TTBL*. Note that echo modes can be specified for full sixteen-bit NS characters (see page 2.12).

*MODE* should be one of the litatoms **IGNORE**, **REAL**, **SIMULATE**, or **INDICATE** which specify how the character should be echoed or printed:

**IGNORE** *CHARCODE* is never printed.

**REAL** *CHARCODE* itself is printed. Some terminals may respond to certain control and meta characters in interesting ways.

**SIMULATE** Output of *CHARCODE* is simulated. For example, control-I (tab) may be simulated by printing spaces. The simulation is machine-specific and beyond the control of the user.

**INDICATE** For control or meta characters, *CHARCODE* is printed as # and/or ↑ followed by the corresponding alphabetic character. For example, control-A would echo as **↑A**, and meta-control-W would echo as **#↑W**.

The value of **ECHOCHAR** is the previous echo mode for *CHARCODE*. If *MODE* = **NIL**, **ECHOCHAR** returns the current echo mode without changing it.

Warning: In some fonts, control and meta characters may be used for printable characters. If the echomode is set to **INDICATE** for these characters, they will not print out correctly.

**(ECHOCONTROL** *CHAR MODE TTBL***)** [Function]

**ECHOCONTROL** is an old, limited version of **ECHOCHAR**, that can only specify the echo mode of control characters. *CHAR* is a character or character code. If *CHAR* is an alphabetic character (or code), it refers to the corresponding control character, e.g., **(ECHOCONTROL 'Z 'INDICATE)** if equivalent to **(ECHOCHAR (CHARCODE ↑Z) 'INDICATE)**.

**(ECHOMODE** *FLG TTBL***)** [Function]

If *FLG* = **T**, turns echoing for terminal table *TTBL* on. If *FLG* = **NIL**, turns echoing off. Returns the previous setting.

Note: Unlike **ECHOCHAR**, this only affects echoing of typed-in characters, not printing of characters.

**(GETECHOMODE** *TTBL***)** [Function]

Returns the current echo mode for *TTBL*.

The following functions manipulate the "raise mode," which determines whether lower case characters are converted to upper case when input from the terminal. There is no "raise mode" for input from files.

**(RAISE** *FLG TTBL***)** [Function]

Sets the **RAISE** mode for terminal table *TTBL*. If *FLG* = **NIL**, all characters are passed as typed. If *FLG* = **T**, input is echoed as typed, but lowercase letters are converted to upper case. If *FLG* = **0**, input is converted to upper case *before* it is echoed. Returns the previous setting.

**(GETRAISE** *TTBL***)** [Function]

Returns the current **RAISE** mode for *TTBL*.

**(DELETECONTROL** *TYPE MESSAGE TTBL***)** [Function]

Specifies the output protocol when a **CHARDELETE** or **LINEDELETE** is typed, by specifying character strings to print when characters are deleted.

Interlisp-10 (designed for use on hardcopy terminals) echos the characters being deleted, preceding the first by a \ and following the last by a \, so that it is easy to see exactly what was deleted. Note: Interlisp-D is initially set up to physically erase the deleted characters from the display, so the **DELETECONTROL** strings are initialized to the null string.

The various values of *TYPE* specify different phases of the deletion, as follows:

**1STCHDEL** *MESSAGE* is the message printed the first time **CHARDELETE** is typed. Initially "\" in Interlisp-10.

**NTHCHDEL** *MESSAGE* is the message printed when the second and subsequent **CHARDELETE** characters are typed (without intervening characters). Initially "" in Interlisp-10.

**POSTCHDEL** *MESSAGE* is the message printed when input is resumed following a sequence of one or more **CHARDELETE** characters. Initially "\" in Interlisp-10.

**EMPTYCHDEL** *MESSAGE* is the message printed when a **CHARDELETE** is typed and there are no characters in the buffer. Initially "##$^{cr}$" in Interlisp-10.

**ECHO** If *TYPE* = **ECHO**, the characters deleted by **CHARDELETE** are echoed. *MESSAGE* is ignored.

**NOECHO** If *TYPE* = **NOECHO**, the characters deleted by **CHARDELETE** are not echoed. *MESSAGE* is ignored.

**LINEDELETE** *MESSAGE* is the message printed when the **LINEDELETE** character is typed. Initially "##$^{cr}$".

Note: In Interlisp-10, the **LINEDELETE, 1STCHDEL, NTHCHDEL, POSTCHDEL,** and **EMPTYCHDEL** messages must be 4 characters or fewer in length.

**DELETECONTROL** returns the previous message as a string. If *MESSAGE* = **NIL**, the value returned is the previous message without changing it. For *TYPE* = **ECHO** and **NOECHO**, the value of **DELETECONTROL** is the previous echo mode, i.e., **ECHO** or **NOECHO**.

**(GETDELETECONTROL** *TYPE TTBL***)** [Function]

Returns the current **DELETECONTROL** mode for *TYPE* in *TTBL*.

### 30.2.3 Line-Buffering

Characters typed at the terminal are stored in two buffers before they are passed to an input function. All characters typed in are put into the low-level "system buffer", which allows type-ahead. When an input function is entered, characters are transferred to the "line buffer" until a character with terminal syntax class **EOL** appears (or, for calls from **READ**, when the count of unbalanced open parentheses reaches 0). Note that **PEEKC** is an exception; it returns the character immediately when its second argument is **NIL**. Until this time, the user can delete characters one at a time from the line buffer by typing the current **CHARDELETE** character, or delete the entire line buffer back to the last carriage-return by typing the current **LINEDELETE**.

Note that this line editing is *not* performed by **READ** or **RATOM**, but by Interlisp, i.e., it does not matter (nor is it necessarily known) which function will ultimately process the characters, only that they are still in the Interlisp line buffer. However, the function that is requesting input at the time the buffering starts does determine whether parentheses counting is observed. For example, if a program performs **(PROGN (RATOM) (READ))** and the user types in "**A (B C D)**", the user must type in the carriage-return following the right parenthesis before any action is taken, because the line buffering is happening under **RATOM**. If the program had performed **(PROGN (READ) (READ))**, the line-buffering would be under **READ**, so that the right parenthesis would terminate line buffering, and no terminating carriage-return would be required.

Once a carriage-return has been typed, the entire line is "available" even if not all of it is processed by the function initiating the request for input. If any characters are "left over", they are returned immediately on the next request for input. For example, **(LIST (RATOM) (READC) (RATOM))** when the input is "**A B**$^{cr}$" returns the three-element list **(A % B)** and leaves the carriage-return in the buffer.

If a carriage-return is typed when the input under **READ** is not "complete" (the parentheses are not balanced or a string is in progress), line buffering continues, but the lines completed so far are not available for editing with **CHARDELETE** or **LINEDELETE**.

The function **CONTROL** is available to defeat line-buffering:

**(CONTROL** *MODE TTBL***)** [Function]

If *MODE* = **T**, eliminates Interlisp's normal line-buffering for the terminal table *TTBL*. If *MODE* = **NIL**, restores line-buffering (normal). When operating with a terminal table in which **(CONTROL T)** has been performed, characters are returned to the calling function without line-buffering as described below.

**CONTROL** returns its previous setting.

**(GETCONTROL** *TTBL***)** [Function]

Returns the current control mode for *TTBL*.

The function that initiates the request for input determines how the line is treated when **(CONTROL T)** is in effect:

**READ** If the expression being typed is a list, the effect is the same as though done with **(CONTROL NIL)**, i.e., line-buffering continues until a carriage-return or matching parentheses. If the expression being typed is not a list, it is returned as soon as a break or separator character is encountered, e.g., **(READ)** when the input is "**ABC**<space>" immediately returns **ABC**. **CHARDELETE** and **LINEDELETE** are available on those characters still in the buffer. Thus, if a program is performing several reads under **(CONTROL T)**, and the user types "**NOW IS THE TIME**" followed by control-Q, only **TIME** is deleted, since the rest of the line has already been transmitted to **READ** and processed.

An exception to the above occurs when the break or separator character is an opening parenthesis, bracket or double-quote, since returning at this point would leave the line buffer in a "funny" state. Thus if the input to **(READ)** is "**ABC(**", the **ABC** is not read until a carriage-return or matching parentheses is encountered. In this case the user could **LINEDELETE** the entire line, since all of the characters are still in the buffer.

**RATOM** Characters are returned as soon as a break or separator character is encountered. Until then, **LINEDELETE** and **CHARDELETE** may be used as with **READ**. For example, **(RATOM)** followed by "**ABC**<control-A><space>" returns **AB**. **(RATOM)** followed by "**(**<control-A>" returns **(** and types **##** indicating that control-A was attempted with nothing in the buffer, since the **(** is a break character and would therefore already have been read.

**READC**
**PEEKC** The character is returned immediately; no line editing is possible. In particular, **(READC)** is perfectly happy to return the

**CHARDELETE** or **LINEDELETE** characters, or the **ESCAPE** character (%).

The system buffer and line buffer can be directly manipulated using the following functions.

**(CLEARBUF** *FILE FLG***)** [Function]

Clears the input buffer for *FILE*. If *FILE* is **T** and *FLG* is **T**, the contents of Interlisp's system buffer and line buffer are saved (and can be obtained via **SYSBUF** and **LINBUF** described below).

When control-D or control-E is typed, or any of the interrupt characters that require terminal interaction is typed (control-G, or control-P), Interlisp automatically performs **(CLEARBUF T T)**. For control-P and, when the break is exited normally, control-H, Interlisp restores the buffer after the interaction.

The action of **(CLEARBUF T)**, i.e., clearing of typeahead, is also available as the **RUBOUT** interrupt character, initially assigned to the delete key in Interlisp-D. Note that this interrupt clears both buffers at the time it is *typed*, whereas the action of the **CHARDELETE** and **LINEDELETE** character occur at the time they are *read*.

**(SYSBUF** *FLG***)** [Function]

If *FLG* = **T**, returns the contents of the system buffer (as a string) that was saved at the last **(CLEARBUF T T)**. If *FLG* = **NIL**, clears this internal buffer.

**(LINBUF** *FLG***)** [Function]

Same as **SYSBUF** for the line buffer.

If both the system buffer and Interlisp's line buffer are empty, the internal buffers associated with **LINBUF** and **SYSBUF** are not changed by a **(CLEARBUF T T)**.

**(BKSYSBUF** *X FLG RDTBL***)** [Function]

**BKSYSBUF** sets the system buffer to the **PRIN1**-name of *X*. The effect is the same as though the user typed *X*. Some implementations have a limit on the length of *X*, in which case characters in *X* beyond the limit are ignored. Returns *X*.

If *FLG* is *T*, then the **PRIN2**-name of *X* is used, computed with respect to the read table *RDTBL*.

Note that if the user is typing at the same time as the **BKSYSBUF** is being performed, the relative order of the type-in and the characters of *X* is unpredictable.

Compatibility note: Some implementations of **BKSYSBUF** (Interlisp-10) use a "system" buffer, from which keyboard interrupts are also processed. In this case, **BKSYSBUF** of an interrupt character actually invokes the interrupt at some (asynchronous) time after the **BKSYSBUF** is initiated. In other implementations (Interlisp-D), the characters are not processed for interrupts, and it is possible to **BKSYSBUF** characters which would otherwise be impossible to type.

**(BKLINBUF** *STR***)** [Function]

*STR* is a string. **BKLINBUF** sets Interlisp's line buffer to *STR*. Some implementations have a limit on the length of *STR*, in which case characters in *STR* beyond the limit are ignored. Returns *STR*.

**BKLINBUF**, **BKSYSBUF**, **LINBUF**, and **SYSBUF** provide a way of "undoing" a **CLEARBUF**. Thus to "peek" at various characters in the buffer, one could perform **(CLEARBUF T T)**, examine the buffers via **LINBUF** and **SYSBUF**, and then put them back.

The more common use of these functions is in saving and restoring typeahead when a program requires some unanticipated (from the user's standpoint) input. The function **RESETBUFS** provides a convenient way of simply clearing the input buffer, performing an interaction with the user, and then restoring the input buffer.

**(RESETBUFS** $FORM_1$ $FORM_2$ ... $FORM_N$**)** [NLambda NoSpread Function]

Clears any typeahead (ringing the terminal's bell if there was, indeed, typeahead), evaluates $FORM_1$, $FORM_2$,... $FORM_N$, then restores the typeahead. Returns the value of $FORM_N$. Compiles open.

## 30.3 Dribble Files

A dribble file is a "transcript" of all of the input and output on a terminal. In Interlisp-D, **DRIBBLE** opens a dribble file for the current process, recording the terminal input and output for that process. Multiple processes can have separate dribble files open at the same time.

**(DRIBBLE** *FILE APPENDFLG THAWEDFLG***)** [Function]

Opens *FILE* and begins recording the typescript. Returns the old dribble file if any, otherwise **NIL**. If *APPENDFLG* = **T**, the typescript will be appended to the end of *FILE*. If *THAWEDFLG* = **T**, the file will be opened in "thawed" mode, for those implementations that support it. **(DRIBBLE)** closes the dribble file for the current process. Only one dribble file can be active for each process at any one time, so **(DRIBBLE** *FILE1***)** followed by **(DRIBBLE** *FILE2***)** will cause *FILE1* to be closed.

**(DRIBBLEFILE)** [Function]

Returns the name of the current dribble file for the current process, if any, otherwise **NIL**.

Terminal input is echoed to the dribble file a line buffer at a time. Thus, the typescript produced is somewhat neater than that appearing on the user's terminal, because it does *not* show characters that were erased via control-A or control-Q. Note that the typescript file is *not* included in the list of files returned by **(OPENP)**, nor will it be closed by a call to **CLOSEALL** or **CLOSEF**. Only **(DRIBBLE)** closes the typescript file.

## 30.4 Cursor and Mouse

A mouse is a small box connected to the computer keyboard by a long wire. On the top of the mouse are two or three buttons. On the bottom is a rolling ball or a set of photoreceptors, to detect when the mouse is moved. As the mouse is moved on a surface, a small image on the screen, called the cursor, moves to follow the movement of the mouse. By moving the mouse, the user can cause the cursor to point to any part of the display screen.

The mouse and cursor are an important part of the Interlisp-D user interface. The Interlisp-D window system allows the user to create, move, and reshape windows, and to select items from displayed menus, all by moving the mouse and clicking the mouse buttons. This section describes the low-level functions used to control the mouse and cursor.

### 30.4.1 Changing the Cursor Image

Interlisp-D maintains the image of the cursor on the screen, moving it as the mouse is moved. The bitmap that becomes visible as the cursor can be accessed by the following function:

**(CURSORBITMAP)** [Function]

Returns the cursor bitmap.

**CURSORWIDTH** [Variable]

**CURSORHEIGHT** [Variable]

Value is the width and height of the cursor bitmap, respectively.

The cursor bitmap can be changed like any other bitmap by **BITBLT**ing into it or pointing a display stream at it and printing or drawing curves. However, for some applications it is necessary to save and restore the cursor, which can be most easily done using **CURSOR** record objects. A **CURSOR** record contains fields **CURSORBITMAP** and **CURSORHOTSPOT**. The value of the **CURSORBITMAP** field is a bitmap that is **CURSORWIDTH** bits wide by **CURSORHEIGHT** high. The value of the **CURSORHOTSPOT** field is the "hot spot" of the cursor, a position in the bitmap interpreted as the point that the cursor is pointing to. **CURSOR** objects can be saved on a file using the file package command **CURSORS**, or the **UGLYVARS** file package command.

**(CURSORCREATE** *BITMAP X Y***)** [Function]

Returns a cursor object which has *BITMAP* as its image and the location (*X*,*Y*) as the hot spot. If *X* is a **POSITION**, it is used as the hot spot. If *BITMAP* has dimensions different from **CURSORWIDTH** by **CURSORHEIGHT**, the lesser of the widths and the lesser of the heights are used to determine the bits that actually get copied into the lower left corner of the cursor. If *X* is **NIL**, 0 is used. If *Y* is **NIL**, **CURSORHEIGHT**-1 is used. The default cursor is an uparrow with its tip in the upper left corner and its hot spot at (0,**CURSORHEIGHT**-1).

**(CURSOR** *NEWCURSOR —***)** [Function]

Returns a **CURSOR** record instance that contains (a copy of) the current cursor specification. If *NEWCURSOR* is a **CURSOR** record instance, the cursor will be set to the values in *NEWCURSOR*. If *NEWCURSOR* is **T**, the cursor will be set to the default cursor **DEFAULTCURSOR**, an upward left pointing arrow: .

**(SETCURSOR** *NEWCURSOR —***)** [Function]

If *NEWCURSOR* is a **CURSOR** record instance, the cursor will be set to the values in *NEWCURSOR*. This does not return the old cursor, and therefore, provides a way of changing the cursor without using storage.

**(FLIPCURSOR)** [Function]

Inverts the cursor.

The following list describes the cursors used by the Interlisp-D system. Most of them are stored as the values of various variables.


In variable **DEFAULTCURSOR**. This is the default cursor.


In variable **WAITINGCURSOR**. Represents an hourglass. Used during long computations.


In variable **MOUSECONFIRMCURSOR**. Indicates that the system is waiting for the user to confirm an action by pressing the left mouse button, or aborting the action by pressing any other button. Used by the function **MOUSECONFIRM** (page 28.11).

In variable **SYSOUTCURSOR**. Indicates that the system is saving the virtual memory in a sysout file. See **SYSOUT**, page 12.8.

In variable **SAVINGCURSOR**. Indicates that **SAVEVM** has been called automatically to save the virtual memory state after the system is idle for long enough. See **SAVEVMWAIT**, page 12.7.


In variable **CROSSHAIRS**. Used by **GETPOSITION** (page 28.9) to indicate a position.


In variable **BOXCURSOR**. Used by **GETBOXPOSITION** (page 28.9) to indicate where to place the corner of a box.


In variable **FORCEPS**. Used by **GETREGION** (page 28.10) when the user switches corners.


In variable **EXPANDINGBOX**. Used by **GETREGION** (page 28.10) when a box is first displayed.


In variable **UpperRightCursor**.


In variable **LowerRightCursor**.


In variable **UpperLeftCursor**.


In variable **LowerLeftCursor**.

The previous four cursors are used by **GETREGION** (page 28.10) to indicate the four corners of a region.


In variable **VertThumbCursor**. Used during scrolling to indicate thumbing in a vertical scroll bar.


In variable **VertScrollCursor**.


In variable **ScrollUpCursor**.


In variable **ScrollDownCursor**.

The previous four cursors are used by **SCROLL.HANDLER** (page 28.24) during vertical scrolling.

In variable **HorizThumbCursor**. Used during scrolling to indicate thumbing in a horizontal scroll bar.

In variable **HorizScrollCursor**.

In variable **ScrollLeftCursor**.

In variable **ScrollRightCursor**.

The previous four cursors are used by **SCROLL.HANDLER** (page 28.24) during horizontal scrolling.

TELE RAID, ↑D, ↑N, CMD
CA
Raid, Brk, NFT

These cursors are used by the Teleraid low-level debugger. These cursors are not accessable as standard Interlisp-D cursors.

## 30.4.2 Flashing Bars on the Cursor

The low-level Interlisp-D system uses the cursor to display certain system status information, such as garbage collection or swapping. This is done because changing the cursor image is very quick, and does not require interacting with the window system. Interlisp inverts horizontal bars on the cursor when the system is swapping pages, or doing certain stack operations. Normally, these bars are only inverted for a very short time, so they look like they are flashing. These cursor changes are interpreted as follows:

Inverted cursor:

Whatever image is being displayed as the cursor, whenever Interlisp does a garbage collection, the whole cursor is inverted.

Top bar:

Swap read. On when Interlisp is swapping in a page from the virtual memory file into the real memory. It is also on when Interlisp allocates a new virtual memory page, even though that doesn't involve a disk read. If this is flashing a lot, the system is doing a lot of swapping. This is an indication that the virtual memory working set is fragmented (see page 22.1). Performance may be improved by reloading a clean Interlisp system.

Upper middle bar:

Stack operations. If this is flashing a lot, it suggests that some process is neglecting to release stack pointers in a timely fashion (see page 11.9).

Lowereler middle bar:

Stack operations. On when Interlisp is moving frames on the stack. If the system is slow, and this is flashing a lot, **HARDRESET** (page 23.1) sometimes helps.

Bottom bar:

Swap write. On when Interlisp writes a dirty virtual memory page from the real memory back into the virtual memory file.

### 30.4.3 Cursor Position

The position at which the cursor bitmap is being displayed can be read or set using the following functions:

**(CURSORPOSITION** *NEWPOSITION DISPLAYSTREAM OLDPOSITION***)** [Function]

Returns the location of the cursor in the coordinate system of *DISPLAYSTREAM* (or the current display stream, if *DISPLAYSTREAM* is **NIL**). If *NEWPOSITION* is non-**NIL**, it should be a position and the cursor will be positioned at *NEWPOSITION*. If *NEWPOSITION* is **NIL**, the current position is simple returned.

Note: The current position of the cursor is the position of the "hot spot" of the cursor, not the position of the cursor bitmap.

If *OLDPOSITION* is a **POSITION** object, this object will be changed to point to the location of the cursor and returned, rather of allocating a new **POSITION**. This can improve performance if **CURSORPOSITION** is called repeatedly to track the cursor.

Note: To get the location of the cursor in absolute screen coordinates, use the variables **LASTMOUSEX** and **LASTMOUSEY** (page 30.18).

**(ADJUSTCURSORPOSITION** *DELTAX DELTAY***)** [Function]

Moves the cursor *DELTAX* points in the X direction and *DELTAY* points in the Y direction. *DELTAX* and *DELTAY* default to 0.

### 30.4.4 Mouse Button Testing

There are two or three keys on the mouse. These keys (also called buttons) are referred to by their location: **LEFT**, **MIDDLE**, or **RIGHT**. The following macros are provided to test the state of the mouse buttons:

**(MOUSESTATE** *BUTTONFORM***)** [Macro]

Reads the state of the mouse buttons, and returns **T** if that state is described by *BUTTONFORM*. *BUTTONFORM* can be one of the key indicators **LEFT**, **MIDDLE**, or **RIGHT**; the atom **UP** (indicating all keys are up); the form **(ONLY** *KEY***)**; or a form of **AND**, **OR**, or **NOT** applied to any valid button form.

For example: **(MOUSESTATE LEFT)** will be true if the left mouse button is down. **(MOUSESTATE (ONLY LEFT))** will be true if the left mouse button is the only one down. **(MOUSESTATE (OR (NOT LEFT) MIDDLE))** will be true if either the left mouse button is up or the middle mouse button is down.

**(LASTMOUSESTATE** ***BUTTONFORM*****)** [Macro]

Similar to **MOUSESTATE,** but tests the value of **LASTMOUSEBUTTONS** (below) rather than getting the current state. This is useful for determining which keys caused **MOUSESTATE** to be true.

**(UNTILMOUSESTATE** ***BUTTONFORM INTERVAL*****)** [Macro]

*BUTTONFORM* is as described in **MOUSESTATE**. Waits until *BUTTONFORM* is true or until *INTERVAL* milliseconds have elapsed. The value of **UNTILMOUSESTATE** is **T** if *BUTTONFORM* was satisfied before it timed out, otherwise **NIL**. If *INTERVAL* is **NIL**, it waits indefinitely. This compiles into an open loop that calls the **TTY** wait background function. This form should not be used inside the **TTY** wait background function. **UNTILMOUSESTATE** does not use any storage during its wait loop.

## 30.4.5 Low Level Mouse Functions

This section describes the functions and variables that provide low level access to the mouse and cursor.

**(LASTMOUSEX** ***DISPLAYSTREAM*****)** [Function]

Returns the value of the cursor's X position in the coordinates of *DISPLAYSTREAM* (as of the last call to **GETMOUSESTATE**, below).

**(LASTMOUSEY** ***DISPLAYSTREAM*****)** [Function]

Returns the value of the cursor's Y position in the coordinates of *DISPLAYSTREAM* (as of the last call to **GETMOUSESTATE**, below).

**LASTMOUSEX** [Variable]

Value is the X position of the cursor in absolute screen coordinates (as of the last call to **GETMOUSESTATE**, below).

**LASTMOUSEY** [Variable]

Value is the Y position of the cursor in absolute screen coordinates (as of the last call to **GETMOUSESTATE**, below).

**LASTMOUSEBUTTONS** [Variable]

Value is an integer that has bits on corresponding to the mouse buttons that are down (as of the last call to **GETMOUSESTATE**, below). Bit **4Q** is the left mouse button, **2Q** is the right button, **1Q** is the middle button.

**LASTKEYBOARD** [Variable]

Value is an integer encoding the state of certain keys on the keyboard (as of the last call to **GETMOUSESTATE**, below). Bit **200Q** = lock, **100Q** = left shift, **40Q** = ctrl, **10Q** = right shift, **4Q** = blank Bottom, **2Q** = blank Middle, **1Q** = blank Top. If the key is down, the corresponding bit is on.

**(GETMOUSESTATE)** [Function]

Reads the current state of the mouse and sets the variables **LASTMOUSEX**, **LASTMOUSEY**, and **LASTMOUSEBUTTONS**. In polling mode, the program must remember the previous state and look for changes, such as a key going up or down, or the cursor moving outside a region of interest.

**(DECODEBUTTONS** ***BUTTONSTATE*****)** [Function]

Returns a list of the mouse buttons that are down in the state *BUTTONSTATE*. If *BUTTONSTATE* is not a small integer, the value of **LASTMOUSEBUTTONS** (above) is used. The button names that can be returned are: **LEFT**, **MIDDLE**, **RIGHT** (the three mouse keys).

## 30.5 Keyboard Interpretation

For each key on the keyboard and mouse there is a corresponding bit in memory that the hardware turns on and off as the key moves up and down. System-level routines decode the meaning of key transitions according to a table of "key actions", which may be to put particular character codes in the sysbuffer, cause interrupts, change the internal shift/control status, or create events to be placed in the mouse buffer.

**(KEYDOWNP** ***KEYNAME*****)** [Function]

Used to read the instantaneous state of any key, independent of any buffering or pre-assigned key action. Returns **T** if the key named *KEYNAME* is down at the moment the function is executed.

Most keys are named by the characters on the key-top. Therefore, **(KEYDOWNP 'a)** or **(KEYDOWNP 'A)** returns **T** if the "**A**" key is down.

There are a number of keys that do not have standard names printed on them. These can be accessed by special names as follows:

| | |
|---|---|
| Space | **SPACE** |
| Carriage return | **CR** |

| | |
|---|---|
| Line-feed | **LF** |
| Backspace | **BS** |
| Tab | **TAB** |
| Blank keys on 1132 | The 1132 keyboard has three unmarked keys on the right of the normal keyboard. These can be accessed by **BLANK-BOTTOM**, **BLANK-MIDDLE**, and **BLANK-TOP**. |
| Escape | **ESCAPE** |
| Shift keys | **LSHIFT** for the left shift key, **RSHIFT** for the right shift key. |
| Shift lock key | **LOCK** |
| Control key | **CTRL** |
| Mouse buttons | The state of the mouse buttons can be accessed using **LEFT**, **MIDDLE**, and **RIGHT**. |

**(SHIFTDOWNP** ***SHIFT*****)** [Function]

Returns *T* if the internal "shift" flag specified by *SHIFT* is on; **NIL** otherwise.

If *SHIFT* = **1SHIFT**, **2SHIFT**, **LOCK**, **META**, or **CTRL**, **SHIFTDOWNP** returns the state of the left shift, right shift, shift lock, control, and meta flags, respectively.

If *SHIFT* = **SHIFT**, **SHIFTDOWNP** returns **T** if either the left or right shift flag is on.

If *SHIFT* = **USERMODE1**, **USERMODE2**, or **USERMODE3**, **SHIFTDOWNP** returns the state of one of three user-settable flags that have no other effect on key interpretation. These flags can be set or cleared on character transitions by using **KEYACTION** (below).

**(KEYACTION** ***KEYNAME ACTIONS*** **—)** [Function]

Changes the internal tables that define the action to be taken when a key transition is detected by the system keyboard handler. *KEYNAME* is specified as for **KEYDOWNP**. *ACTIONS* is a dotted pair of the form (*DOWN-ACTION* . *UP-ACTION*), where the acceptable transition actions and their interpretations are:

| | |
|---|---|
| **NIL**<br>**IGNORE** | Take no action on this transition (the default for up-transitions on all ordinary characters). |
| (*CHAR SHIFTEDCHAR LOCKFLAG*) | If a transition action is a three-element list, *CHAR* and *SHIFTEDCHAR* are either character codes or (non-numeric) single-character litatoms standing for their character codes. Note that *CHAR* and *SHIFTEDCHAR* can be full sixteen-bit NS characters (see page 2.12). When the transition occurs, *CHAR* or *SHIFTEDCHAR* is transmitted to the system buffer, depending on whether either of the two shift keys are down. |

*LOCKFLAG* is optional, and may be **LOCKSHIFT** or **NOLOCKSHIFT**. If *LOCKFLAG* is **LOCKSHIFT**, then *SHIFTEDCHAR* will also be transmitted when the **LOCK** shift is down (the alphabetic keys initially specify **LOCKSHIFT**, but the digit keys specify **NOLOCKSHIFT**). For example, **(a A LOCKSHIFT)** and **(61Q ! NOLOCKSHIFT)** are the initial settings for the down transitions of the "**a**" and "**1**" keys respectively.

**1SHIFTUP, 1SHIFTDOWN**
**2SHIFTUP, 2SHIFTDOWN**
**CTRLUP, CTRLDOWN**
**METAUP, METADOWN**

Change the status of the internal "shift" flags for the left shift, right shift, control, and meta keys, respectively. These shifts affect the interpretation of ordinary key actions. If either of the shifts is down, then *SHIFTEDCHAR*s are transmitted. If the control flag is on, then the the seventh bit of the character code is cleared as characters are transmitted. If the meta flag is on, the the eighth bit of the character code is set (normally cleared) as characters are transmitted. For example, the initial keyactions for the left shift key is **(1SHIFTDOWN . 1SHIFTUP)**.

**LOCKUP, LOCKDOWN, LOCKTOGGLE**

Change the status of the internal "shift" flags for the shift lock key. If the lock flag is down, then *SHIFTEDCHAR*s are transmitted if the key action specified **LOCKSHIFT**. **LOCKUP** and **LOCKDOWN** clear and set the shift lock flag, respectively. **LOCKTOGGLE** complements the flag (turning it off if the flag is on; on if the flag is off).

**USERMODE1UP, USERMODE1DOWN, USERMODE1TOGGLE**
**USERMODE2UP, USERMODE2DOWN, USERMODE2TOGGLE**
**USERMODE3UP, USERMODE3DOWN, USERMODE3TOGGLE**

Change the status of the three user flags **USERMODE1**, **USERMODE2**, and **USERMODE3**, whose status can be determined by calling **SHIFTDOWNP** (above). These flags have no other effect on key interpretation.

**EVENT**

An encoding of the current state of the mouse and selected keys is placed in the mouse-event buffer when this transition is detected.

**KEYACTION** returns the previous setting for *KEYNAME*. If *ACTIONS* is **NIL**, returns the previous setting without changing the tables.

**(MODIFY.KEYACTIONS** *KEYACTIONS SAVECURRENT?***)** [Function]

*KEYACTIONS* is a list of key actions to be set, each of the form (*KEYNAME . ACTIONS*). The effect of **MODIFY.KEYACTIONS** is as if **(KEYACTION** *KEYNAME ACTIONS***)** were performed for each item on *KEYACTIONS*.

If *SAVECURRENT?* is non-**NIL**, then **MODIFY.KEYACTIONS** returns a list of all the results from **KEYACTION**, otherwise it returns **NIL**.

This can be used with a **MODIFY.KEYACTIONS** that appears in a **RESETFORM**, so that the list is built at "entry", but not upon "exit".

**(METASHIFT *FLG*)** [NoSpread Function]

If *FLG* is **T**, changes the keyboard handler (via **KEYACTION**) so as to interpret the "stop" key on the 1108 as a metashift: if a key is struck while the meta is down, it is read with the 200Q bit set. For CHAT users this is a way of getting an "Edit" key on your simulated Datamedia.

If *FLG* is other than **NIL** or **T**, it is passed as the *ACTIONS* argument to **KEYACTION**. The reason for this is that if someone has set the "STOP" key to some random behavior, then **(RESETFORM (METASHIFT T) --)** will correctly restore that random behavior.

# 30.6 Display Screen

Interlisp-D supports a high-resolution bitmap display screen. All printing and drawing operations to the screen are actually performed on a bitmap in memory, which is read by the computer hardware to become visible as the screen. This section describes the functions used to control the appearance of the display screen.

**(SCREENBITMAP)** [Function]

Returns the screen bitmap.

**SCREENWIDTH** [Variable]

**SCREENHEIGHT** [Variable]

Value is the width and height of the screen bitmap, respectively.

**WHOLEDISPLAY** [Variable]

Value is a region that is the size of the screen bitmap.

The background shade of the display window can be changed using the following function:

**(CHANGEBACKGROUND *SHADE* —)** [Function]

Changes the background shade of the window system. *SHADE* determines the pattern of the background. If *SHADE* is a texture, then the background is simply painted with it. If *SHADE* is a **BITMAP**, the background is tesselated (tiled) with it to cover the screen. If *SHADE* is **T**, it changes to the original shade, the value of **WINDOWBACKGROUNDSHADE**. It returns the previous value of the background.

**(CHANGEBACKGROUNDBORDER** *SHADE* **—)** [Function]

On the Xerox 1108, changes the shade of the border of the display to *SHADE*, which should be a texture. It returns the previous texture of the background border. **CHANGEBACKGROUNDBORDER** is a no-op on the Xerox 1132.

**WINDOWBACKGROUNDSHADE** [Variable]

Value is the default background shade for the display.

**(VIDEOCOLOR** *BLACKFLG***)** [NoSpread Function]

Sets the interpretation of the bits in the screen bitmap. If *BLACKFLG* is **NIL**, a 0 bit will be displayed as white, otherwise a 0 bit will be displayed as black. **VIDEOCOLOR** returns the previous setting. If *BLACKFLG* is not given, **VIDEOCOLOR** will return the current setting without changing anything.

Note: This function only works on the Xerox 1100 and Xerox 1108.

**(VIDEORATE** *TYPE***)** [Function]

Sets the rate at which the screen is refreshed. *TYPE* is one of **NORMAL** or **TAPE**. If *TYPE* is **TAPE**, the screen will be refreshed at the same rate as TV (60 cycles per second). This makes the picture look better when video taping the screen. Note: Changing the rate may change the dimensions of the display on the picture tube.

Maintaining the video image on the screen uses cpu cycles, so turning off the display can improve the speed of compute-bound tasks. When the display is off, the screen will be white but any printing or displaying that the program does will be visible when the display is turned back on. Note: Breaks and **PAGEFULLFN** waiting (page 28.30) turn the display on, but users should be aware that it is possible to have the system waiting for a response to a question printed or a menu displayed on a non-visible part of the screen. The functions below are provided to turn the display off.

Note: These functions have no effect on the Xerox 1108 display.

**(SETDISPLAYHEIGHT** *NSCANLINES***)** [Function]

Sets the display to only show the top *NSCANLINES* of the screen. If *NSCANLINES* is **T**, resets the display to show the full screen. Returns the previous setting.

**(DISPLAYDOWN** *FORM NSCANLINES***)** [Function]

Evaluates *FORM* (with the display set to only show the top *NSCANLINES* of the screen), and returns the value of *FORM*. It restores the screen to its previous setting. If *NSCANLINES* is not given, it defaults to 0.

# 30.7 Miscellaneous Terminal I/O

**(RINGBELLS** *N***)** [Function]

Flashes (reverse-videos) the screen *N* times (default 1). On the Xerox 1108, this also beeps through the keyboard speaker.

**(PLAYTUNE** *Frequency/Duration.pairlist***)** [Function]

On the Xerox 1108, **PLAYTUNE** plays a sequence of notes through the keyboard speaker. *Frequency/Duration.pairlist* should be a list of dotted pairs (*FREQUENCY . DURATION*). **PLAYTUNE** maps down its argument, beeping the 1108 keyboard buzzer at each frequency for the specified amount of time. Specifying **NIL** for a frequency means to turn the beeper off the specified amount of time. The units of time are **TICKS** (page 12.16), which last about 28.78 microseconds on the Xerox 1108. **PLAYTUNE** makes no sound on a Xerox 1132. The default "simulate" entry for control-G (ASCII BEL) on the 1108 uses **PLAYTUNE** to make a short beep.

**PLAYTUNE** is implemented using **BEEPON** and **BEEPOFF**:

**(BEEPON** *FREQ***)** [Function]

On the Xerox 1108, turns on the keyboard speaker playing a note with frequency *FREQ*, measured in **TICKS** (page 12.16). The speaker will continue to play the note until **BEEPOFF** is called.

**(BEEPOFF)** [Function]

Turns off the keyboard speaker on the Xerox 1108.

**(SETMAINTPANEL** *N***)** [Function]

On the Xerox 1108, this sets the four-digit "maintanance panel" display on the front of the computer to display the number *N*.

# 31. ETHERNET

Interlisp was first developed on large timesharing machines which provided each user with access to large amounts of disk storage, printers, mail systems, etc. Interlisp-D, however, was designed to run on smaller, single-user machines without these facilities. In order to provide Interlisp-D users with access to all of these services, Interlisp-D supports the Ethernet communications network, which allows multiple Interlisp-D machines to share common printers, file servers, etc.

Interlisp-D supports the Experimental Ethernet (3 Megabits per second) and the Ethernet (10 Megabits per second) local communications networks. These networks may be used for accessing file servers, remote printers, mail servers, or other machines. This chapter is divided into three sections: First, an overview of the various Ethernet and Experimental Ethernet protocols is presented. Then follow sections documenting the functions used for implementing PUP and NS protocols at various levels.

## 31.1 Ethernet Protocols

The members of the Xerox 1100 family (1108, 1132), Xerox file servers and laser xerographic printers, along with machines made by other manufacturers (most notably DEC) have the capability of communicating over 3 Megabit per second Experimental Ethernets, 10 Megabit per second Ethernets and telephone lines.

Xerox pioneered its work with Ethernet using a set of protocols known as PARC Universal Packet (PUP) computer communication protocols. The architecture has evolved into the newer Network Systems (NS) protocols developed for use in Xerox office products. All of the members of the Xerox 1100 family can use both NS and PUP protocols.

### 31.1.1 Protocol Layering

The communication protocols used by the members of the Xerox 1100 family are implemented in a "layered" fashion, which means that different levels of communication are implemented as different protocol layers. Protocol Layering allows implementations of specific layers to be changed without requiring changes to any other layers. The layering also allows use of the same higher level software with different lower levels of protocols. Protocol designers can implement new types of protocols at the correct protocol level for their specific application in a layered system.

At the bottom level, level zero, there is a need to physically transmit data from one point to another. This level is highly dependent on the particular transmission medium involved. There are many different level zero protocols, and some of them may contain several internal levels. At level one, there is a need to decide where the data should go. This level is concerned with how to address a source and destination, and how to choose the correct transmission medium to use in order to route the packet towards its destination. A level one packet is transmitted by *encapsulating* it in the level zero packet appropriate for the transmission medium selected. For each independent communication protocol system, a single level one protocol is defined. The rule for delivery of a level one packet is that the communication system must only make a best effort to deliver the packet. There is no guarantee that the packet is delivered, that the packet is not duplicated and delivered twice, or that the packets will be delivered in the same order as they were sent.

The addresses used in level zero and level one packets are not necessarily the same. Level zero packets are specific to a particular transmission medium. For example, the destination address of a level zero packet transmitted on one of the two kinds of Ethernet is the Ethernet address (host number) of a machine on the particular network. Level one packets specify addresses meaningful to the particular class of protocols being implemented. For the PUP and NS protocols, the destination address comprises a network number, host number (not necessarily the same as the level zero host number), and a socket number. The socket number is a higher-level protocol concept, used to multiplex packets arriving at a single machine destined for separate logical processes on the machine.

Protocols in level two add order and reliability to the level one facilities. They suppress duplicate packets, and are responsible for retransmission of packets for which acknowledgement has not been received. The protocol layers above level two add conventions for data structuring, and implement application specific protocols.

## 31.1.2 Level Zero Protocols

Level zero protocols are used to physically connect computers. The addresses used in level zero protocols are protocol specific.

The Ethernet and Experimental Ethernet level zero protocols use host numbers, but level zero phone line protocols contain less addressing information since there are only two hosts connected to the telephone line, one at each end. As noted above, a level zero protocol does not include network numbers.

The 3MB Experimental Ethernet [1] was developed at PARC. Each Experimental Ethernet packet includes a source and destination host address of eight bits. The Experimental Ethernet standard is used by any machine attached to an Experimental Ethernet.

The 10MB Ethernet [2] was jointly developed and standardized by Digital, Intel, and Xerox. Each Ethernet level zero packet includes a source and destination host address that is 48 bits long. The Ethernet standard is used by any machine attached to an Ethernet.

Both of the level one protocols described later (PUP and NS) can be transported on any of the level zero protocols described above.

The Ethernet and Experimental Ethernet protocols are broadcast mediums. Data packets can be sent on these networks to every host attached to the net. A packet directed at every host on a network is a broadcast packet.

Other Level 0 protocols in use in industry include X.25, broadband networks, and Chaosnet. In addition, by using the notion of "mutual encapsulation", it is possible to treat a higher-level protocol (e.g. ARPANET) as if it were a Level Zero Protocol.

### 31.1.3 Level One Protocols

Two Level One Protocols are used in the Xerox 1100 Family, the PUP and the NS protocols. With the proper software, computers attached to Ethernets or Experimental Ethernets can send PUPs and NS packets to other computers on the same network, and to computers attached to other Ethernets or Experimental Ethernets.

The PUP protocols [3] were designed by Xerox computer scientists at the Palo Alto Research Center. The destination and source addresses in a PUP packet are specified using an 8-bit network number, an 8-bit host number, and a 32-bit socket number. The 8-bit network number allows an absolute maximum of 256 PUP networks in an internet. The 8-bit host number is network relative. That is, there may be many host number "1"s, but only one per network. 8 bits for the host number limits the number of hosts per network to 256. The socket number is used for further levels of addressing within a specific machine.

The Network Systems (NS) protocols [4, 5] were developed by the Xerox Office Products Division. Each NS packet address includes a 32-bit network number, a 48-bit host number, and a 16-bit socket number. The NS host and network numbers are unique through all space and time. A specific NS host number is generally assigned to a machine when it is manufactured, and is never changed. In the same fashion, all networks (including those sold by Xerox and those used within Xerox) use the same network numbering space---there is only one network "74".

### 31.1.4 Higher Level Protocols

The higher level PUP protocols include the File Transfer Protocol (FTP) and the Leaf Protocol used to send and retrieve files from Interim File Servers (IFSs) and DEC File Servers, the Telnet protocol implemented by "Chat" windows and servers, and the EFTP protocol used to communicate with the laser xerographic printers developed by PARC ("Dovers" and "Penguins").

The higher level NS protocols include the Filing Protocol which allows workstations to access the product File Services sold by Xerox, the Clearinghouse Protocol used to access product Clearinghouse Services, and the TelePress Protocol used to communicate with the Xerox model 8044 Print Server.

### 31.1.5 Connecting Networks: Routers and Gateways

When a level one packet is sent from one machine to another, and the two machines are not on the same network, the packet must be passed between networks. Computers that are connected to two or more level zero mediums are used for this function. In the PUP world, these machines have been historically called "Gateways." In the NS world these machines are called Internetwork Routers (Routers), and the function is packaged and sold by Xerox as the Internetwork Routing Service (IRS).

Every host that uses the PUP protocols requires a PUP address; NS Hosts require NS addresses. An address consists of two parts: the host number and the network number. A computer learns its network number by communicating with a Router or Gateway that is attached to the same network. Host number determination is dependent on the hardware and the type of host number, PUP or NS.

Note that there is absolutely no relationship between a host's NS host and net numbers and the same host's PUP host and net numbers.

### 31.1.6 Addressing Conflicts with Level Zero Mediums

For convenience in the respective protocols, a level one PUP (8-bit) host number is the same as a level zero Experimental Ethernet host number; i.e., when a PUP level one packet is transported by an Experimental Ethernet to another host on the same network, the level zero packet specifies the same host number as the level one packet. Similarly, a level one NS (48-bit) host number is the same as a level zero Ethernet host number.

When a PUP level one packet is transported by an Ethernet, or an NS level one packet is sent on Experimental Ethernet, the level one host number cannot be used as the level zero address, but rather some means must be provided to determine the correct level zero address. Xerox solved this problem by specifying another level-one protocol called *translation* to allow hosts on an Experimental Ethernet to announce their NS host numbers, or hosts on an Ethernet to announce their PUP host numbers. Thus, both the Ethernet and Experimental Ethernet Level Zero Protocols totally support both families of higher level protocols.

### 31.1.7 References

[1] Robert M. Metcalfe and David R. Boggs, Ethernet: Distributed Packet Switching for Local Computer Networks, *Communications of the ACM*, vol. 19 no. 7, July 1976.

[2] Digital Equipment Corporation, Intel Corporation, Xerox Corporation. The Ethernet, A Local Area Network: Data Link Layer and Physical Layer Specifications. September 30, 1980, Version 1.0

[3] D. R. Boggs, J. F. Shoch, E. A. Taft, and R. M. Metcalfe, PUP: An Internetwork Architecture, *IEEE Transactions on Communications*, com-28:4, April 1980.

[4] Xerox Corporation. Courier: The Remote Procedure Call Protocol. Xerox System Integration Standard. Stamford, Connecticut, December, 1981, XSIS 038112.

[5] Xerox Corporation. Internet Transport Protocols. Xerox System Integration Standard. Stamford, Connecticut, December, 1981, XSIS 028112.

## 31.2 Higher-level PUP Protocol Functions

This section describes some of the functions provided in Interlisp-D to perform protocols above Level One. Level One functions are described in a later section, for the benefit of those users who wish to program new protocols.

**(ETHERHOSTNUMBER** *NAME***)** [Function]

Returns the number of the named host. The number is 16-bit quantity, the high 8 bits designating the net and the low 8 bits the host. If *NAME* is **NIL**, returns the number of the local host.

**(ETHERPORT** *NAME ERRORFLG MULTFLG***)** [Function]

Returns a port corresponding to *NAME*. A "port" is a network address that represents (potentially) one end of a network connection, and includes a socket number in addition to the network and host numbers. Most network functions that take a port as argument allow the socket to be zero, in which case a well-known socket is supplied. A port is currently represented as a dotted pair (*NETHOST* . *SOCKET*).

*NAME* may be a litatom, in which case its address is looked up, or a port, which is just returned directly. If *ERRORFLG* is true, generates an error "host not found" if the address lookup fails, else it returns **NIL**. If *MULTFLG* is true, returns a list of alternative port specifications for *NAME*, rather than a single port (this is provided because it is possible for a single name in the name database to have multiple addresses). If *MULTFLG* is **NIL** and *NAME* has more than one address, the currently nearest one is returned. **ETHERPORT** caches its results.

The *SOCKET* of a port is usually zero, unless the name explicitly contains a socket designation, a number or symbolic name following a + in *NAME*, e.g., **PHYLUM + LEAF**. A port can also be specified in the form "*NET#HOST#SOCKET*", where each of *NET*, *HOST* and *SOCKET* is a sequence of octal digits; the socket, but not the terminating #, can be omitted, in which case the socket is zero.

**(ETHERHOSTNAME** *PORT USE.OCTAL.DEFAULT***)** [Function]

Looks up the name of the host at address *PORT*. *PORT* may be a numeric address, a (*NETHOST* . *SOCKET*) pair returned from **ETHERPORT**, or a numeric designation in string form, "*NET#HOST#SOCKET*", as described above. In the first case, the net defaults to the local net. If *PORT* is **NIL**, returns the name of the local host. If there is no name for the given port, but *USE.OCTAL.DEFAULT* is true, the function returns a string specifying the port in octal digits, in the form "*NET#HOST#SOCKET*", with *SOCKET* omitted if it is zero. Most functions that take a port argument will also accept ports in this octal format.

**(EFTP** ***HOST FILE PRINTOPTIONS*****)** [Function]

Transmits *FILE* to *HOST* using the **EFTP** protocol. The *FILE* need not be open on entry, but in any case is closed on exit. **EFTP** returns only on success; if *HOST* does not respond, it keeps trying.

The principal use of the **EFTP** protocol is for transmitting Press files to a printer. If *PRINTOPTIONS* is non-**NIL**, **EFTP** assumes that *HOST* is a printer and *FILE* is a Press file, and takes additional action: it calls **PRINTERSTATUS** (page 29.4) for *HOST* and prints this information to the prompt window; and it fills in the "printed-by" field on the last page of the press file with the value of **USERNAME** (page 24.40). Also, *PRINTOPTIONS* is interpreted as a list in property list format that controls details of the printing. Possible properties are as follows:

**#COPIES** Value is the number copies of the file to print. Default is one.

**#SIDES** If the value is 2, select two-sided printing (if the printer can print two-sided copies).

**DOCUMENT.CREATION.DATE** Value is the document creation date to appear on the header page (an integer date as returned by **IDATE**).

**DOCUMENT.NAME** Value is the document name to appear on the header page (as a string). Default is the full name of the file.

## 31.3 Higher-level NS Protocol Functions

The following is a description of the Interlisp-D facilities for using Xerox SPP and Courier protocols and the services based on them. The sections on naming conventions, Printing, and Filing are of general interest to users of Network Systems servers. The remaining sections describe interfaces of interest to those who wish to program other applications on top of either Courier or SPP.

### 31.3.1 Name and Address Conventions

Addresses of hosts in the NS world consist of three parts, a network number, a machine number, and a socket number. These three parts are embodied in the Interlisp-D data type **NSADDRESS**. Objects of type **NSADDRESS** print as "net#h1.h2.h3#socket", where all the numbers are printed in octal radix, and the 48-bit host number is broken into three

16-bit fields. Most functions that accept an address argument will accept either an **NSADDRESS** object or a string that is the printed representation of the address.

Higher-level functions accept host arguments in the form of a symbolic name for the host. The NS world has a hierarchical name space. Each object name is in three parts: the *Organization*, the *Domain*, and the *Object* parts. There can be many domains in a single organization, and many objects in a single domain. The name space is maintained by the *Clearinghouse*, a distributed network database service.

A Clearinghouse name is standardly notated as *object*:*domain*:*organization*. The parts *organization* or *domain*:*organization* may be omitted if they are the default (see below). Alphabetic case is not significant. Internally, names are represented as objects of data type **NSNAME**, but most functions accept the textual representation as well, either as a litatom or a string. Objects of type **NSNAME** print as *object*:*domain*:*organization*, with fields omitted when they are equal to the default. A *Domain* is standardly represented as an **NSNAME** in which the object part is null. If frequent use is to be made of an NS name, it is generally preferable to convert it to an **NSNAME** once, by calling **PARSE.NSNAME**, then passing the resultant object to all functions desiring it.

**CH.DEFAULT.ORGANIZATION** [Variable]

This is a string specifying the default Clearinghouse organization.

**CH.DEFAULT.DOMAIN** [Variable]

This is a string specifying the default Clearinghouse domain. If it or the variable **CH.DEFAULT.ORGANIZATION** is **NIL**, they are set by Lisp system code (when they are needed) to be the first domain served by the nearest Clearinghouse server.

In small organizations with just one domain, it is reasonable to just leave these variables **NIL** and have the system set them appropriately. In organizations with more than one domain, it is wise to set them in the site initialization file, so as not to be dependent on exactly which Clearinghouse servers are up at any time.

**(PARSE.NSNAME** *NAME #PARTS DEFAULTDOMAIN***)** [Function]

When *#PARTS* is 3 (or **NIL**), parses *NAME*, a litatom or string, into its three parts, returning an object of type **NSNAME**. If the domain or organization is omitted, defaults are supplied, either from *DEFAULTDOMAIN* (an **NSNAME** whose domain and organization fields only are used) or from the variables **CH.DEFAULT.DOMAIN** and **CH.DEFAULT.ORGANIZATION**.

If *#PARTS* is 2, *NAME* is interpreted as a domain name, and an **NSNAME** with null object is returned. In this case, if *NAME* is a full 3-part name, the object part is stripped off.

If *#PARTS* is 1, *NAME* is interpreted as an organization name, and a simple string is returned. In this case, if *NAME* is a 2- or 3-part name, the organization is extracted from it.

If *NAME* is already an object of type **NSNAME**, then it is returned as is (if *#PARTS* is 3), or its domain and/or organization parts are extracted (if *#PARTS* is 1 or 2).

**(NSNAME.TO.STRING** *NSNAME FULLNAMEFLG***)** [Function]

Converts *NSNAME*, an object of type **NSNAME**, to its string representation. If *FULLNAMEFLG* is true, the full printed name is returned; otherwise, fields that are equal to the default are omitted.

Programmers who wish to manipulate **NSADDRESS** and **NSNAME** objects directly should load the Library package **ETHERRECORDS**.

### 31.3.2 Clearinghouse Functions

This section describes functions that may be used to access information in the Clearinghouse.

**(START.CLEARINGHOUSE** *RESTARTFLG***)** [Function]

Performs an expanding ring broadcast in order to find the nearest Clearinghouse server, whose address it returns. If a Clearinghouse has already been located, this function simply returns its address immediately, unless *RESTARTFLG* is true, in which case the cache of Clearinghouse information is invalidated and a new broadcast is performed. **START.CLEARINGHOUSE** is normally performed automatically by the system the first time it needs Clearinghouse information; however, it may be necessary to call it explicitly (with *RESTARTFLG* set) if the local Clearinghouse server goes down.

**CH.NET.HINT** [Variable]

A number or list of numbers, giving a hint as to which network the nearest Clearinghouse server is on. When **START.CLEARINGHOUSE** looks for a Clearinghouse server, it probes the network(s) given by **CH.NET.HINT** first, performing the expanding ring broadcast only if it fails there. If the nearest Clearinghouse server is not on the directly connected network, setting **CH.NET.HINT** to the proper network number in the local site init file (page 12.1) can speed up **START.CLEARINGHOUSE** considerably.

**(SHOW.CLEARINGHOUSE** *ENTIRE.CLEARINGHOUSE? DONT.GRAPH***)** [Function]

This function displays the structure of the cached Clearinghouse information in a window. Once created, it will be redisplayed whenever the cache is updated, until the window is closed. The structure is shown using the Library package **GRAPHER**.

If *ENTIRE.CLEARINGHOUSE?* is true, then this function probes the Clearinghouse to discover the entire domain:organization structure of the Internet, and graphs the result. If *DONT.GRAPH* is true, the structure is not graphed, but rather the results are returned as a nested list indicating the structure.

**(LOOKUP.NS.SERVER** *NAME TYPE FULLFLG***)** [Function]

Returns the address, as an **NSADDRESS**, for the object *NAME*. *TYPE* is the property under which the address is stored, which defaults to **ADDRESS.LIST**. The information is cached so that it need not be recomputed on each call; the cache is cleared by restarting the Clearinghouse. If *FULLFLG* is true, returns a list whose first element is the canonical name of *NAME* and whose tail is the address list.

The following functions perform various sorts of retrieval operations on database entries in the Clearinghouse. Here, "The Clearinghouse" refers to the collective service offered by all the Clearinghouse servers on an internet; Lisp internally deals with which actual server(s) it needs to contact to obtain the desried information. The argument(s) describing the objects under consideration can be strings or **NSNAME**'s, and in most cases can contain the wild card "*", which matches a subsequence of zero or more characters. Wildcards are permitted only in the most specific field of a name (e.g., in the object part of a full three-part name). When an operation intended for a single object is instead given a pattern, the operation is usually performed on the first matching object in the database, which may or may not be interesting.

**(CH.LOOKUP.OBJECT** *OBJECTPATTERN***)** [Function]

Looks up *OBJECTPATTERN* in the Clearinghouse database, returning its canonical name (as an **NSNAME**) if found, **NIL** otherwise. If *OBJECTPATTERN* contains a "*", returns the first matching name.

**(CH.LIST.ORGANIZATIONS** *ORGANIZATIONPATTERN***)** [Function]

Returns a list of organization names in the Clearinghouse database matching *ORGANIZATIONPATTERN*. The default pattern is "*", which matches anything.

**(CH.LIST.DOMAINS** *DOMAINPATTERN***)** [Function]

Returns a list of domain names (two-part **NSNAME**'s) in the Clearinghouse database matching *DOMAINPATTERN*. The default pattern is "*", which matches anything in the default organization.

**(CH.LIST.OBJECTS** *OBJECTPATTERN PROPERTY***)** [Function]

Returns a list of object names matching *OBJECTPATTERN* and having the property *PROPERTY*. *PROPERTY* is a number or a symbolic name for a Clearinghouse property; the latter include **USER, PRINT.SERVICE, FILE.SERVICE, MEMBERS, ADDRESS.LIST** and **ALL**.

For example,

**(CH.LIST.OBJECTS "*:PARC:Xerox" (QUOTE USER))**

returns a list of the names of users in the domain PARC:Xerox.

**(CH.LIST.OBJECTS "*lisp*:PARC:Xerox" (QUOTE MEMBERS))**

returns a list of all group names in PARC:Xerox containing the substring "lisp".

**(CH.LIST.ALIASES** *OBJECTNAMEPATTERN***)** [Function]

Returns a list of all objects in the Clearinghouse database that are aliases and match *OBJECTNAMEPATTERN*.

**(CH.LIST.ALIASES.OF** *OBJECTPATTERN***)** [Function]

Returns a list of all objects in the Clearinghouse database that are aliases of *OBJECTPATTERN*.

**(CH.RETRIEVE.ITEM** *OBJECTPATTERN PROPERTY INTERPRETATION***)** [Function]

Retrieves the value of the *PROPERTY* property of *OBJECTPATTERN*. Returns a list of two elements, the canonical name of the object and the value. If *INTERPRETATION* is given, it is a Clearinghouse type (see page 31.19) with which to interpret the bits that come back; otherwise, the value is simply of the form **(SEQUENCE UNSPECIFIED)**, a list of 16-bit integers representing the value.

**(CH.RETRIEVE.MEMBERS** *OBJECTPATTERN PROPERTY —***)** [Function]

Retrieves the members of the group *OBJECTPATTERN*, as a list of **NSNAME**s. *PROPERTY* is the Clearinghouse Group property under which the members are stored; the usual property used for this purpose is **MEMBERS**.

**(CH.ISMEMBER** *GROUPNAME PROPERTY SECONDARYPROPERTY NAME***)** [Function]

Tests whether *NAME* is a member of *GROUPNAME*'s *PROPERTY* property. This is a potentially complex operation; see the description of procedure **IsMember** in the Clearinghouse Protocol documentation for details.

## 31.3.3 NS Printing

This section describes the facilities that are available for printing Interpress masters on NS Print servers.

**(NSPRINT** *PRINTER FILE OPTIONS***)** [Function]

This function prints an Interpress master on *PRINTER*, which is a Clearinghouse name represented as a string or **NSNAME**. If *PRINTER* is **NIL**, **NSPRINT** uses the first print server registered in the default domain. *FILE* is the name of an Interpress file to be printed. *OPTIONS* is a list in property list format that controls details of the printing (see **SEND.FILE.TO.PRINTER**, page 29.1).

**(NSPRINTER.STATUS** *PRINTER***)** [Function]

This function returns a list describing the printer's current status; whether it is available or busy, and what kind of paper is loaded.

**(NSPRINTER.PROPERTIES** *PRINTER***)** [Function]

This function returns a list describing the printer's capabilities at the moment; the type of paper loaded, whether it can print two-sided, etc.

## 31.3.4 SPP Stream Interface

This section describes the stream interface to the Sequenced Packet Protocol. SPP is the transport protocol for Courier, which in turn is the transport layer for Filing and Printing.

**(SPP.OPEN** *HOST SOCKET PROBEP NAME PROPS***)** [Function]

This function is used to open a bidirectional SPP stream. There are two cases: user and server.

User: If *HOST* is specified, an SPP connection is initiated to *HOST*, an **NSADDRESS** or string representing an NS address. If the socket part of the address is null (zero), it is defaulted to *SOCKET*. If both *HOST* and *PROBEP* are specified, then the connection is probed for a response before returning the stream; **NIL** is returned if *HOST* doesn't respond.

Server: If *HOST* is **NIL**, a passive connection is created which listens for an incoming connection to local socket *SOCKET*.

**SPP.OPEN** returns the input side of the bidirectional stream; the function **SPPOUTPUTSTREAM** is used to obtain the output side. The standard stream operations **BIN**, **READP**, **EOFP** (on the input side), and **BOUT**, **FORCEOUTPUT** (on the output side), are defined on these streams, as is **CLOSEF**, which can be applied to either stream to close the connection.

*NAME* is a mnemonic name for the connection process, mainly useful for debugging.

*PROPS* is an optional property list, used to set the properties that determine the behavior of the SPP stream when certain events occur. The following properties can be specified:

**CLOSEFN** A function or list of functions called (with the stream as argument) when an SPP connection is closed.

**ATTENTIONFN** A function called (with the stream as argument) when an ATTENTION packet is received on the SPP connection.

**ERRORHANDLER** A function called (with the stream as argument) when an error (such as end-of-stream) occurs on the SPP connection.

**OTHERXIPHANDLER** A function called (with the stream as argument) when a non-SPP, non-error packet is received on the socket associated with the SPP connection.

**EOM.ON.FORCEOUTPUT** The value of this property should be either **T** or **NIL** (the default). If **T**, then the end-of-message bit is set when the current collection of bytes buffered for transmission is forcibly sent (e.g. by **FORCEOUTPUT**, page 25.10).

**SERVER.FUNCTION** This property can be used for creating SPP servers. Normally, when a connection is opened with the *HOST* argument set to **NIL**, a passive "listener" connection is created. **SPP.OPEN** will not return until some other host attempts to connect to socket specified in the **SPP.OPEN** call.

If the **SERVER.FUNCTION** property is specified, a new listener (and listener process) is created. **SPP.OPEN** will return immediately. Whenever another host attempts to connect to the specified socket, a new process and unique SPP connection are created. The function specified by the **SERVER.FUNCTION** property is run in the top level of the new process. The server function should be a function of two arguments: the first argument is the SPP input stream associated with the connection; the second argument is the SPP output stream associated with the connection.

**(SPPOUTPUTSTREAM *STREAM*)** [Function]

Applied to the input stream of an SPP connection, this function returns the corresponding output stream.

**SPP.USER.TIMEOUT** [Variable]

Specifies the time, in milliseconds, to wait before deciding that a host isn't responding.

**(SPP.DSTYPE *STREAM DSTYPE*)** [Function]

Accesses the current datastream type of the connection. If *DSTYPE* is **NIL**, returns the datastream type of the current packet being read. If *DSTYPE* is non-**NIL**, sets the datastream type of all subsequent packets sent on this connection, until the next call to **SPP.DSTYPE**. Since this affects the current partially-filled packet, the stream should probably be flushed (via **FORCEOUTPUT**) before this function is called.

**(SPP.SENDEOM *STREAM*)** [Function]

Transmits the data buffered so far on the output stream *STREAM*, if any, with the End of Message bit set. If there is nothing buffered, sends a zero-length packet with the End of Message bit set.

**(SPP.SENDATTENTION *STREAM ATTENTIONBYTE* —)** [Function]

Sends an SPP "attention" packet on the output stream *STREAM*, with the Attention bit set and containing the single byte of data *ATTENTIONBYTE*.

Note: The appropriate way to determine whether an SPP stream is open, or whether an End of Message or Attention indication has been reached (for input streams) is to use the **EOFP** function (page 25.6). When **EOFP** is applied to an SPP stream, it returns one of the following values:

**NIL** The connection is open and readable or writable.

**T** The connection is closed.

**EOM** (Input streams only) The End of Message bit was set in the last packet received, and all bytes from the packet have been read. The function **SPP.CLEAREOM** (below) must be called to clear this condition.

**ATTENTION** (Input streams only) An attention packet is waiting. **SPP.CLEARATTENTION** (below) must be called before the single byte of data associated with the attention packet can be read.

**(SPP.CLEAREOM** *STREAM NOERRORFLG***)** [Function]

Clears the End of Message indication on *STREAM*. This is necessary in order to read beyond the EOM. Causes an error if the stream is not currently at the End of Message, unless *NOERRORFLG* is non-**NIL**.

**(SPP.CLEARATTENTION** *STREAM NOERRORFLG***)** [Function]

Clears the Attention packet indication on *STREAM*. This must be called before the single byte of data associated with the attention packet can be read. Causes an error if the stream does not have an attention packet waiting, unless *NOERRORFLG* is non-**NIL**.

## 31.3.5 Courier Remote Procedure Call Protocol

Courier is the Xerox Network Systems Remote Procedure Call protocol. It uses the Sequenced Packet Protocol for reliable transport. Courier uses procedure call as a metaphor for the exchange of a request from a user process and its positive reply from a server process; exceptions or error conditions are the metaphor for a negative reply. A family of remote procedures and the errors they can raise constitute a remote program. A remote program generally represents a complete service, such as the Filing or Printing programs described earlier in this chapter.

For more detail about Courier, the reader is referred to the published specification of the Courier protocol. The following documentation assumes some familiarity with the protocol. It describes how to define a Courier program and use it to communicate with a remote system element that implements a server for that program. This section does not discuss how to construct such a server.

### 31.3.5.1 Defining Courier Programs

A Courier program definition is accessed using the file package type **COURIERPROGRAMS**, so **GETDEF**, **PUTDEF**, and **EDITDEF** can be used to manipulate Courier programs. The file package command **COURIERPROGRAMS** (page 17.39) can be used to save Courier programs on files. Courier program are initially defined using the following function:

**(COURIERPROGRAM** *NAME* ...**)** [NLambda NoSpread Function]

This function is used to define Courier programs. The syntax is

**(COURIERPROGRAM** *NAME*
  **(***PROGRAMNUMBER VERSIONNUMBER***)**
  . *DEFINITIONS***)**

The tail *DEFINITIONS* is a property list where the properties are selected from **TYPES, PROCEDURES, ERRORS** and **INHERITS**; the values are lists of pairs of the form (*LABEL . DEFINITION*). These are described in more detail as follows:

The **TYPES** section lists the symbolically-defined types used to represent the arguments and results of procedures and errors in this Courier program. Each element in this section is of the form (*TYPENAME TYPEDEFINITION*), e.g., **(PRIORITY INTEGER)**. The *TYPEDEFINITION* can be a predefined type (see next section), another type defined in this **TYPES** section, or a qualified typename taken from another Courier program; these latter are written as a dotted pair (*PROGRAMNAME . TYPENAME*).

The **PROCEDURES** section lists the remote procedures defined by this Courier program. A procedure definition is a stylized reduction of the Courier definition syntax defined in the Courier Protocol specification:

**(***PROCEDURENAME NUMBER ARGUMENTS*
    **RETURNS** *RESULTTYPES* **REPORTS** *ERRORNAMES***)**

*ARGUMENTS* is a list of type names, one per argument to the remote procedure, or **NIL** if the procedure takes no arguments. *RESULTTYPES* is a list of type names, one for each value to be returned. *ERRORNAMES* is a list of names of errors that can be raised by this procedure; each such error must be listed in the program's **ERRORS** section. The atoms **RETURNS** and **REPORTS** are noise words to aid readability.

The **ERRORS** section lists the errors that can be raised by procedures in this program. An error definition is of the form

**(***ERRORNAME NUMBER ARGUMENTS***)**,

where *ARGUMENTS* is a list of type names, one for each argument, if any, reported by the error.

The **INHERITS** section is an optional list of other Courier programs, some of whose definitions are "inherited" by this program. More specifically, if a type, procedure or error referenced in the current program definition is not defined in this program, the system searches for a definition of it in each of the inherited programs in turn, and uses the first such definition found.

The **INHERITS** section is useful when defining variants of a given Courier program. For example, if one wanted to try out version 4 of Courier program **BAR**, and version 4 differed from version 3 of program **BAR** only in a small number of procedure or type definitions, one could define a program **NEWBAR** with an **INHERITS** section of **(BAR)** and only need to list the few changed definitions inside **NEWBAR**.

### 31.3.5.2 Courier Type Definitions

This section describes how the Courier types described in the Courier Protocol document are expressed in a Lisp Courier program definition, and how values of each type are represented. Each type in a Courier program's **TYPES** section must ultimately be defined in terms of one of the following "base" types, although the definition can be indirect through arbitrarily many levels. That is, a type can be defined in terms of any other type known by an extant Courier definition. The names of the base types are "global"; they need no qualification, nor do type names mentioned in the same Courier program. To refer to a type not defined in the same Courier program (or to any non-base type when there is no program context), one writes a *Qualified name*, in the form (*PROGRAM* . *TYPE*). In general, a Qualified name is legal in any place that calls for a Courier type.

#### 31.3.5.2.1 Pre-defined Types

Pre-defined (atomic) types are expressed as uppercase litatoms from the following set:

**BOOLEAN** Values are represented by **T** and **NIL**.

**INTEGER** Values are represented as small integers in the range [-32768..32767].

**CARDINAL** Values are represented as small integers in the range [0..65535].

**UNSPECIFIED** Same as **CARDINAL**.

**LONGINTEGER** Values are represented as **FIXP**'s.

**LONGCARDINAL** Same as **LONGINTEGER**. Note that Interlisp-D does not (currently) have a datatype that truly represents a 32-bit *unsigned* integer.

**STRING** Values are represented as Lisp strings.

In addition, the following types not in the document have been added for convenience:

**TIME** Represents a date and time in accordance with the Network Time Standard. The value is a **FIXP** such as returned by the function **IDATE**, and is encoded as a **LONGCARDINAL**.

**NSADDRESS** Represents a network address. The value is an object of type **NSADDRESS** (page 31.7), and is encoded as six items of type **UNSPECIFIED**.

**NSNAME** Represents a three-part Clearinghouse name. The value is an object of type **NSNAME** (page 31.8), and is encoded as three items of type **STRING**.

**NSNAME2** Represents a two-part Clearinghouse name, i.e., a domain. The value is an object of type **NSNAME** (page 31.8), and is encoded as two items of type **STRING**.

### 31.3.5.2.2 Constructed Types

Constructed Types are composite objects made up of elements of other types. They are all expressed as a list whose **CAR** names the type and whose remaining elements give details. The following are available:

**(ENUMERATION (*NAME INDEX*) ... (*NAME INDEX*))**
Each *NAME* is an arbitrary litatom or string; the corresponding *INDEX* is its Courier encoding (a **CARDINAL**). Values of type **ENUMERATION** are represented as a *NAME* from the list of choices. For example, a value of type **(ENUMERATION (UNKNOWN 0) (RED 1) (BLUE 2))** might be the litatom **RED**.

**(SEQUENCE *TYPE*)** A **SEQUENCE** value is represented as a list, each element being of type *TYPE*. A **SEQUENCE** of length zero is represented as **NIL**. Note that there is no maximum length for a **SEQUENCE** in the Lisp implementation of Courier.

**(ARRAY *LENGTH TYPE*)** An **ARRAY** value is represented as a list of *LENGTH* elements, each of type *TYPE*.

**(CHOICE (*NAME INDEX TYPE*) ... (*NAME INDEX TYPE*))**
The **CHOICE** type allows one to select among several different types at runtime; the *INDEX* is used in the encoding to distinguish the value types. A value of type **CHOICE** is represented in Lisp as a list of two elements, (*NAME VALUE*). For example, a value of type

**(CHOICE (STATUS 0 (ENUMERATION (BUSY 0) (COMPLETE 1)))
(MESSAGE 1 STRING))**

could be **(STATUS COMPLETE)** or **(MESSAGE "Out of paper.")**.

**(RECORD (*FIELDNAME TYPE*) ... (*FIELDNAME TYPE*))**
Values of type **RECORD** are represented as lists, with one element for each field of the record. The field names are not part of the value, but are included for documentation purposes.

For programmer convenience, there are two macros that allow Courier records to be constructed and dissected in a manner similar to Lisp records. These compile into the appropriate composites of **CONS, CAR** and **CDR**.

**(COURIER.CREATE** *TYPE FIELDNAME* ← *VALUE* ... *FIELDNAME* ← *VALUE*) [Macro]

Creates a value of type *TYPE*, which should be a fully-qualified type name that designates a **RECORD** type, e.g., **(MAILTRANSPORT . POSTMARK)**. Each *FIELDNAME* should correspond to a field of the record, and all fields must be included. Each *VALUE* is evaluated; all other arguments are not. The assignment arrows are for readability, and are optional.

**(COURIER.FETCH** *TYPE FIELD OBJECT***)** [Macro]

Analogous to the Record Package operator **fetch**. Argument *TYPE* is as with **COURIER.CREATE**; *FIELD* is the name of one of its fields. **COURIER.FETCH** extracts the indicated field from *OBJECT*. For readability, the noiseword "**of**" may be inserted between *FIELD* and *OBJECT*. Only the argument *OBJECT* is evaluated.

For example, if the program **CLEARINGHOUSE** has a type declaration

```
(USERDATA.VALUE (RECORD (LAST.NAME.INDEX CARDINAL)
        (FILE.SERVICE STRING))),
```

then the expression

```
(SETQ INFO (COURIER.CREATE
      (CLEARINGHOUSE . USERDATA.VALUE)
      LAST.NAME.INDEX ← 12
      FILE.SERVICE ← "Phylex:PARC:Xerox")
```

would set the variable **INFO** to the list **(12 "Phylex:PARC:Xerox")**. The expression

```
(COURIER.FETCH (CLEARINGHOUSE . USERDATA.VALUE)
  FILE.SERVICE of INFO)
```

would produce **"Phylex:PARC:Xerox"**.

### 31.3.5.2.3 User Extensions to the Type Language

The programmer can add new base types to the Courier language by telling the system how to read and write values of that type. The programmer chooses a name for the type, and gives the name a **COURIERDEF** property. The new name can then be used anywhere that the type names listed in the previous sections, such as **CARDINAL**, can be used. Such extensions are useful for user-defined objects, such as datatypes, that are not naturally represented by any predefined or constructed type. The **NSADDRESS** and **NSNAME** Courier types are defined by this mechanism.

**COURIERDEF** [Property Name]

The format of the **COURIERDEF** property is a list of up to four elements, (*READFN WRITEFN LENGTHFN WRITEREPFN*). The first two elements are required; if the latter two are omitted, the system will simulate them as needed. The elements are as follows:

*READFN* This is a function of three arguments, (*STREAM PROGRAM TYPE*). The function is called by Courier when it needs to read a value of this type from *STREAM* as part of a Courier transaction. The function reads and returns the value from *STREAM*, possibly using functions such as **COURIER.READ** (page 31.25). *PROGRAM* and *TYPE* are the name of the Courier program and the type. In the case of atomic types, *TYPE* is a litatom, and is provided for type discrimination in case the programmer has supplied a single reading function for several different types. In the case of constructed types, *TYPE* is a list, **CAR** of which is the type name.

*WRITEFN* This is a function of four arguments, (*STREAM VALUE PROGRAM TYPE*). The function is called by Courier when it needs to write *VALUE* to *STREAM*. *PROGRAM* and *TYPE* are as with the reading function. The function should write *VALUE* on *STREAM*. The result returned from this function is ignored.

*LENGTHFN* This function is called when Courier wants to write a value of this type in the form **(SEQUENCE UNSPECIFIED)**, and then only if the *WRITEREPFN* is omitted. The function is of three arguments, (*VALUE PROGRAM TYPE*). It should return, as an integer, the number of 16-bit words that the *WRITEFN* would require to write out this value. If values of this type are all the same length, the *LENGTHFN* can be a simple integer instead of a function. See discussion of **COURIER.WRITE.SEQUENCE.UNSPECIFIED** (page 31.26.

*WRITEREPFN* This function is called when Courier wants to write a value of this type in the form **(SEQUENCE UNSPECIFIED)**. The function takes the same arguments as the *WRITEFN*, but must write the value to the stream preceded by its length. If this function is omitted, Courier invokes the *LENGTHFN* to find out how long the value is, and then invokes the *WRITEFN*. If the *LENGTHFN* is omitted, Courier invokes the *WRITEFN* on a scratch stream to find out how long the value is.

### 31.3.5.3 Performing Courier Transactions

The normal use of Courier is to open a connection with a remote system element using **COURIER.OPEN**, perform one or more remote procedure calls using **COURIER.CALL**, then close the connection with **CLOSEF**.

**(COURIER.OPEN** *HOSTNAME SERVERTYPE NOERRORFLG NAME WHENCLOSEDFN OTHERPROPS*) [Function]

Opens a Courier connection to the Courier socket on *HOST*, and returns an SPP stream that can be passed to **COURIER.CALL**. *HOSTNAME* can be an NS address, or a symbolic Clearinghouse name in the form of a string, litatom or **NSNAME**. In the case of a symbolic name, *SERVERTYPE* specifies the Clearinghouse property under which the server's address may be found; normally, this is **NIL**, in which case the **ADDRESS.LIST** property is used.

Normally, if a connection cannot be made, or the server supports the wrong version of Courier, an error occurs. If *NOERRORFLG* is non-**NIL**, **COURIER.OPEN** returns **NIL** in these cases.

If *NAME* is non-**NIL**, it is used as the name of the Courier connection process.

*WHENCLOSEDFN* is a function (or list of functions) of one argument, the Courier stream, that will be called when the connection is closed, either by user or server.

If *OTHERPROPS* is non-**NIL**, it should be a property list of SPP stream properties, as accepted by **SPP.OPEN** (page 31.12). Any **CLOSEFN** property on this list is overridden by the value of *WHENCLOSEDFN*.

**(COURIER.CALL** *STREAM PROGRAM PROCEDURE* $ARG_1$ ... $ARG_N$ *NOERRORFLG***)** [NoSpread Function]

This function calls the remote procedure *PROCEDURE* of the Courier program *PROGRAM*. *STREAM* is the stream returned by **COURIER.OPEN**. The arguments should be Lisp values appropriate for the Courier types of the corresponding formal parameters of the procedure. There must be the same number of actual and formal arguments. If the procedure call is successful, Courier returns the result(s) of the call as specified in the **RETURNS** section of the procedure definition. If there is only a single result, it is returned directly, otherwise a list of results is returned.

Procedures that take a Bulk Data argument (source or sink) are treated specially; see page 31.24.

If the procedure call results in an error, one of three possible courses is available. The default behavior is to cause a Lisp error. To suppress the error, an optional keyword can be appended to the argument list, as if an extra argument. This *NOERRORFLG* argument can be the atom **NOERROR**, in which case **NIL** is returned as the result of the call. If *NOERRORFLG* is **RETURNERRORS**, the result of the call is a list **(ERROR** *ERRORNAME* . *ERRORARGS***)**. If the failure was a Courier Reject, rather than Error, then *ERRORNAME* is the atom **REJECT**.

Examples:

```
(COURIERPROGRAM PERSONNEL (17 1)
  TYPES
  ((PERSON.NAME (RECORD (FIRST.NAME STRING)
              (MIDDLE MIDDLE.PART)
              (LAST.NAME STRING)))
```

```
  (MIDDLE.PART (CHOICE (NAME 0 STRING)
            (INITIAL 1 STRING)))
  (BIRTHDAY (RECORD (YEAR CARDINAL)
            (MONTH STRING)
            (DAY CARDINAL))))
 PROCEDURES
 ((GETBIRTHDAY 3 (PERSON.NAME)
     RETURNS (BIRTHDAY) REPORTS (NO.SUCH.PERSON)))
 ERRORS
 ((NO.SUCH.PERSON 1))
)
```

This expression defines **PERSONNEL** to be Courier program number 17, version number 1. The example defines three types, **PERSON.NAME**, **MIDDLE.PART** and **BIRTHDAY**, and one procedure, **GETBIRTHDAY**, whose procedure number is 3. The following code could be used to call the remote **GETBIRTHDAY** procedure on the host with address **HOSTADDRESS**.

```
(SETQ STREAM (COURIER.OPEN HOSTADDRESS))
(PROG1 (COURIER.CALL STREAM 'PERSONNEL 'GETBIRTHDAY
           (COURIER.CREATE (PERSONNEL . PERSON.NAME)
               FIRST.NAME ← "Eric"
               MIDDLE ← '(INITIAL "C")
               LAST.NAME ← "Cooper"))
   (CLOSEF STREAM))
```

**COURIER.CALL** in this example might return a value such as **(1959 "January" 10)**.

### 31.3.5.3.1 Expedited Procedure Call

Some Courier servers support "Expedited Procedure Call", which is a way of performing a single Courier transaction by a Packet Exchange protocol, rather than going to the expense of setting up a full Courier connection. Expedited calls must have no bulk data arguments, and their arguments and results must each fit into a single packet.

**(COURIER.EXPEDITED.CALL** *ADDRESS SOCKET# PROGRAM PROCEDURE* $ARG_1$ ... $ARG_N$ *NOERRORFLG*) [NoSpread Function]

Attempts to perform a Courier call using the Expedited Procedure Call. *ADDRESS* is the NS address of the remote host and *SOCKET#* is the socket on which it is known to listen for expedited calls. The remaining arguments are exactly as with **COURIER.CALL**. If the arguments to the procedure do not fit in one packet, or if there is no response to the call, or if the call returns the error **USE.COURIER** (which must be defined by exactly that name in *PROGRAM*), then the call is attempted instead by the normal, non-expedited method—a Courier connection is opened with *ADDRESS*, and **COURIER.CALL** is invoked on the arguments given.

### 31.3.5.3.2 Expanding Ring Broadcast

"Expanding Ring Broadcast" is a method of locating a server of a particular type whose address is not known in advance. The system broadcasts some sort of request packet on the directly-connected network, then on networks one hop away, then on networks two hops away, etc., until a positive response is received.

For use in locating a server for a particular Courier program, a stylized form of Expanding Ring Broadcast is defined. The request packet is essentially the call portion of an Expedited Procedure Call for some procedure defined in the program. The response packet is a Courier response, and typically contains at least the server's address as the result of the call. The designer of the protocol must, of course, specify which procedure to use in the broadcast (usually it is procedure number zero) and on what socket the server should listen for broadcasts.

**START.CLEARINGHOUSE** uses this procedure to locate the nearest Clearinghouse server.

(**COURIER.BROADCAST.CALL** *DESTSOCKET# PROGRAM PROCEDURE ARGS RESULTFN NETHINT MESSAGE*) [Function]

Performs an expanding ring broadcast for servers willing to implement *PROCEDURE* in Courier program *PROGRAM*. *DESTSOCKET#* is the socket on which such servers of this type are known to listen for broadcasts, typically the same socket on which they listen for expedited calls. *ARGS* is the argument list, if any, to the procedure (note that it is not spread, unlike with **COURIER.CALL**).

If a host responds positively, then the function *RESULTFN* is called with one argument, the Courier results of the procedure call. If *RESULTFN* returns a non-null value, the value is returned as the value of **COURIER.BROADCAST.CALL** and the search stops there; otherwise, the search for a responsive host continues. If *RESULTFN* is not supplied (or is **NIL**), then the results of the procedure call are returned directly from **COURIER.BROADCAST.CALL**; i.e., *RESULTFN* defaults to the identity function.

*NETHINT*, if supplied, is a net number or list of net numbers as a hint concerning which net(s) to try first before performing a pure expanding-ring broadcast. If *MESSAGE* is non-NIL, it is a description (string) of what the broadcast is looking for, to be printed in the prompt window to inform the user of what is happening. For example, **START.CLEARINGHOUSE** passes in the message **"Clearinghouse servers"** and the hint **CH.NET.HINT**.

#### 31.3.5.3.3 Using Bulk Data Transfer

When a Courier program needs to transfer an arbitrary amount of information as an argument or result of a Courier procedure, the procedure is usually defined to have one argument of type "Bulk Data". The argument is a "source" if it is information transferred from caller to server (as though a procedure argument), a "sink" if it is information transferred from server to caller (as though a procedure result). These two "types" are indicated in a Courier procedure's formal argument list as **BULK.DATA.SOURCE** and **BULK.DATA.SINK**, respectively. A Courier procedure may have at most one such argument.

In a Courier call, the bulk data is transmitted in a special way, between the arguments and the results. There are two basic ways to handle this in the call. The caller can specify how the bulk data is to be interpreted (how to read or write it), or the caller can request to be given a bulk data stream as the result of the Courier call. The former is the preferred way; both are described below.

In the first method, the caller passes as the actual argument to the Courier call (i.e., in the position in the argument list occupied by **BULK.DATA.SOURCE** or **BULK.DATA.SINK**) a function to perform the transfer. Courier sets up the transaction, then calls the supplied function with one argument, a stream on which to write (if a source argument) or read (if a sink) the bulk data. If the function returns normally, the Courier transaction proceeds as usual; if it errors out, Courier sends a Bulk Data Abort to abort the transaction.

In the case of a sink argument, if the value returned from the sink function is non-**NIL**, it is returned as the result of **COURIER.CALL**; otherwise, the result of **COURIER.CALL** is the usual procedure result, as declared in the Courier program.

For convenience, a Bulk Data sink argument to a Courier call can be specified as a fully qualified Courier type, e.g., **(CLEARINGHOUSE . NAME)**, in which case the Bulk Data stream is read as a "stream of" that type (see **COURIER.READ.BULKDATA**, below).

The second method for handling bulk data is to pass **NIL** as the bulk data "argument" to **COURIER.CALL**. In this case, Courier sets up the call, then returns a stream that is open for **OUTPUT** (if a source argument) or **INPUT** (if a sink). The caller is responsible for transferring the bulk data on the stream, then closing the stream to complete the transaction. The value returned from

**CLOSEF** is the Courier result. This method is required if the caller's control structure is open-ended in a way such that the bulk data cannot be transferred within the scope of the call to **COURIER.CALL**.

In either method, the stream on which the bulk data is transferred is a standard Interlisp stream, so **BIN**, **BOUT**, **COPYBYTES** are all appropriate.

Many Courier programs define a "Stream of <type>" as a means of transferring an arbitrary number of objects, all of the same type. Although this is typically specified formally in the printed Courier documentation as a recursive definition, the recursion is in practice unnecessary and unwieldy; instead, the following function should be used.

**(COURIER.READ.BULKDATA** *STREAM PROGRAM TYPE DONTCLOSE***)** [Function]

Reads from *STREAM* a "Stream of *TYPE*" for Courier program *PROGRAM*, and returns a list of the objects read. *STREAM* is closed on exit, unless *DONTCLOSE* is non-**NIL**.

Passing **(X . Y)** as the bulk argument to a Courier call is thus equivalent to passing the function **(LAMBDA (STREAM) (COURIER.READ.BULKDATA STREAM X Y))**.

### 31.3.5.3.4 Courier Subfunctions for Data Transfer

The following functions are of interest to those who transfer data in Courier representations, e.g., as part of a function to implement a user-defined Courier type.

**(COURIER.READ** *STREAM PROGRAM TYPE***)** [Function]

Reads from the stream *STREAM* a Courier value of type *TYPE* for program *PROGRAM*. If *TYPE* is a predefined type, then *PROGRAM* is irrelevant; otherwise, it is required in order to qualify *TYPE*.

**(COURIER.WRITE** *STREAM ITEM PROGRAM TYPE***)** [Function]

Writes *ITEM* to the stream *STREAM* as a Courier value of type *TYPE* for program *PROGRAM*.

**(COURIER.READ.SEQUENCE** *STREAM PROGRAM TYPE***)** [Function]

Reads from the stream *STREAM* a Courier value **SEQUENCE** of values of type *TYPE* for program *PROGRAM*. Equivalent to **(COURIER.READ** *STREAM PROGRAM* **(SEQUENCE** *TYPE***))**.

**(COURIER.WRITE.SEQUENCE** *STREAM ITEM PROGRAM TYPE***)** [Function]

Equivalent to **(COURIER.WRITE** *STREAM ITEM PROGRAM* **(SEQUENCE** *TYPE***))**.

Some Courier programs traffic in values whose interpretation is left up to the clients of the program; the values are transferred in Courier transactions as values of type **(SEQUENCE UNSPECIFIED)**. For example, the Clearinghouse program transfers the value of a database property as an uninterpreted sequence, leaving it up to the caller, who knows what type of value the particular property takes, to interpret the sequence of raw bits as some other Courier representation. The following functions are useful when dealing with such values.

**(COURIER.WRITE.REP** *VALUE PROGRAM TYPE***)** [Function]

Produces a list of 16-bit integers, i.e., a value of type **(SEQUENCE UNSPECIFIED)**, that represents *VALUE* when interpreted as a Courier value of type *TYPE* in *PROGRAM*. Examples:

**(COURIER.WRITE.REP T NIL 'BOOLEAN) = > (1)**

**(COURIER.WRITE.REP "Thing" NIL 'STRING) = >**
**(5 52150Q 64556Q 63400Q)**

**(COURIER.WRITE.REP '(10 25) NIL '(SEQUENCE INTEGER)) = >**
**(2 10 25)**

**(COURIER.READ.REP** *LIST.OF.WORDS PROGRAM TYPE***)** [Function]

Interprets *LIST.OF.WORDS*, a list of 16-bit integers, as a Courier object of type *TYPE* in the Courier program *PROGRAM*.

**(COURIER.WRITE.SEQUENCE.UNSPECIFIED** *STREAM ITEM PROGRAM TYPE***)** [Function]

Writes to the stream *STREAM* in the form **(SEQUENCE UNSPECIFIED)** the object *ITEM*, whose value is really a Courier value of type *TYPE* for program *PROGRAM*. Equivalent to, but usually much more efficient than, **(COURIER.WRITE** *STREAM* **(COURIER.WRITE.REP** *ITEM PROGRAM TYPE***) NIL '(SEQUENCE UNSPECIFIED))**.

## 31.4 Level One Ether Packet Format

The data type **ETHERPACKET** is the vehicle for all kinds of packets transmitted on an Ethernet or Experimental Ethernet. An **ETHERPACKET** contains several fields for use by the Ethernet drivers and a large, contiguous data area making up the data of the level zero packet. The first several words of the area are reserved for the level one to zero encapsulation, and the remainder (starting at field **EPBODY**) make up the level one packet. Typically, each level one protocol defines a **BLOCKRECORD** (page 8.11) that overlays the **ETHERPACKET** starting at the **EPBODY** field, describing the format of a packet for that particular protocol. For example, the records **PUP** and **XIP** define the format of level one packets in the PUP and NS protocols.

The extra fields in the beginning of an **ETHERPACKET** have mostly a fixed interpretation over all protocols. Among the interesting ones are:

**EPLINK** A pointer used to link packets, used by the **SYSQUEUE** mechanism (page 31.41). Since this field is used by the system for maintaining the free packet queue and ether transmission queues, do not use this field unless you understand it.

**EPFLAGS** A byte field that can be used for any purpose by the user.

**EPUSERFIELD** A pointer field that can be used for any purpose by the user. It is set to **NIL** when a packet is released.

**EPTRANSMITTING** A flag that is true while the packet is "being transmitted", i.e., from the time that the user instructs the system to transmit the packet until the packet is gathered up from the transmitter's finished queue. While this flag is true, the user must *not* modify the packet.

**EPREQUEUE** A pointer field that specifies the desired disposition of the packet after transmission. The possible values are: **NIL** means no special treatment; **FREE** means the packet is to be released after transmission; an instance of a **SYSQUEUE** means the packet is to be enqueued on the specified queue (page 31.41).

The normal life of an outgoing Ether packet is that a program obtains a blank packet, fills it in according to protocol, then sends the packet over the Ethernet. If the packet needs to be retained for possible retransmission, the **EPREQUEUE** field is used to specify a queue to place the packet on after its transmission, or the caller hangs on to the packet explicitly.

There are redefinitions, or "overlays" of the **ETHERPACKET** record specifically for use with the PUP and NS protocols. The following sections describe those records and the handling of the PUP and NS level one protocols, how to add new level one protocols, and the queueing mechanism associated with the **EPREQUEUE** field.

# 31.5 PUP Level One Functions

The functions in this section are used to implement level two and higher PUP protocols. That is, they deal with sending and receiving PUP packets. It is assumed the reader is familiar with the format and use of pups, e.g., from reading reference [3] on page 31.5.

## 31.5.1 Creating and Managing Pups

There is a record **PUP** that overlays the data portion of an **ETHERPACKET** and describes the format of a pup. This record defines the following numeric fields: **PUPLENGTH** (16 bits), **TCONTROL** (transmit control, 8 bits, cleared when a PUP is transmitted), **PUPTYPE** (8 bits), **PUPID** (32 bits), **PUPIDHI** and **PUPIDLO** (16 bits each overlaying **PUPID**), **PUPDEST** (16 bits overlayed by 8-bit fields **PUPDESTNET** and **PUPDESTHOST**), **PUPDESTSOCKET** (32 bits, overlayed by 16-bit fields **PUPDESTSOCKETHI** and **PUPDESTSOCKETLO**), and **PUPSOURCE**, **PUPSOURCENET**, **PUPSOURCEHOST**, **PUPSOURCESOCKET**, **PUPSOURCESOCKETHI**, and **PUPSOURCESOCKETLO**, analagously. The field **PUPCONTENTS** is a pointer to the start of the data portion of the pup.

**(ALLOCATE.PUP)** [Function]

Returns a (possibly used) pup. Keeps a free pool, creating new pups only when necessary. The pup header fields of the pup returned are guaranteed to be zero, but there may be garbage in the data portion if the pup had been recycled, so the caller should clear the data if desired.

**(CLEARPUP** ***PUP*****)** [Function]

Clears *all* information from *PUP*, including the pointer fields of the **ETHERPACKET** and the pup data portion.

**(RELEASE.PUP** ***PUP*****)** [Function]

Releases *PUP* to the free pool.

## 31.5.2 Sockets

Pups are sent and received on a *socket*. Generally, for each "conversation" between one machine and another, there is a distinct socket. When a pup arrives at a machine, the low-level pup software examines the pup's destination socket number. If there is a socket on the machine with that number, the incoming pup is handed over to the socket; otherwise the incoming pup is discarded. When a *user* process initiates a conversation, it generally selects a large, random socket number different from any other in use on the machine. A *server* process, on the other hand, provides a specific service at a "well-known" socket, usually a fairly small number. In the PUP world, advertised sockets are in the range 0 to 100Q.

**(OPENPUPSOCKET** *SKT# IFCLASH***)** [Function]

Opens a new pup socket. If *SKT#* is **NIL** (the normal case), a socket number is chosen automatically, guaranteed to be unique, and probably different from any socket opened this way in the last 18 hours (the low half of the time of day clock is sampled).

If a specific local socket is desired, as is typically the case when implementing a server, *SKT#* is given, and must be a (up to 32-bit) number. *IFCLASH* indicates what to do in the case that the designated socket is already in use: if **NIL**, an error is generated; if **ACCEPT**, the socket is quietly returned; if **FAIL**, then **OPENPUPSOCKET** returns **NIL** without causing an error. Note that "well-known" socket numbers should be avoided unless the caller is actually implementing one of the services advertised as provided at the socket.

**(CLOSEPUPSOCKET** *PUPSOC NOERRORFLG***)** [Function]

Closes and releases socket *PUPSOC*. If *PUPSOC* is **T**, closes all pup sockets (this must be used with caution, since it will also close system sockets!). If *PUPSOC* is already closed, an error is generated unless *NOERRORFLG* is true.

**(PUPSOCKETNUMBER** *PUPSOC***)** [Function]

Returns the socket number (a 32-bit integer) of *PUPSOC*.

**(PUPSOCKETEVENT** *PUPSOC***)** [Function]

Returns the **EVENT** of *PUPSOC* (page 23.7). This event is notified whenever a pup arrives on *PUPSOC*, so pup clients can perform an **AWAIT.EVENT** on this event if they have nothing else to do at the moment.

## 31.5.3 Sending and Receiving Pups

**(SENDPUP** *PUPSOC PUP***)** [Function]

Sends *PUP* on socket *PUPSOC*. If any of the **PUPSOURCESHOST**, **PUPSOURCENET**, or **PUPSOURCESOCKET** fields is zero, **SENDPUP** fills them in using the pup address of this machine and/or the socket number of *PUPSOC*, as needed.

**(GETPUP** *PUPSOC WAIT***)** [Function]

Returns the next pup that has arrived addressed to socket *PUPSOC*. If there are no pups waiting on *PUPSOC*, then **GETPUP** returns **NIL**, or waits for a pup to arrive if *WAIT* is **T**. If *WAIT* is an integer, **GETPUP** interprets it as a number of milliseconds to wait, finally returning **NIL** if a pup does not arrive within that time.

**(DISCARDPUPS** *SOC***)** [Function]

Discards without examination any pups that have arrived on *SOC* and not yet been read by a **GETPUP**.

**(EXCHANGEPUPS** *SOC OUTPUP DUMMY IDFILTER TIMEOUT***)** [Function]

Sends *OUTPUP* on *SOC*, then waits for a responding pup, which it returns. If *IDFILTER* is true, ignores pups whose **PUPID** is different from that of *OUTPUP*. *TIMEOUT* is the length of time (msecs) to wait for a response before giving up and returning **NIL**. *TIMEOUT* defaults to **ETHERTIMEOUT**. **EXCHANGEPUPS** discards without examination any pups that are currently waiting on *SOC* before *OUTPUP* gets sent. (*DUMMY* is ignored; it exists for compatibility with an earlier implementation).

## 31.5.4 Pup Routing Information

Ordinarily, a program calls **SENDPUP** and does not worry at all about the route taken to get the pup to its destination. There is an internet routing process in Lisp whose job it is to maintain information about the best routes to networks of interest. However, there are some algorithms for which routing information and/or the topology of the net are explicitly desired. To this end, the following functions are supplied:

**(PUPNET.DISTANCE** *NET#***)** [Function]

Returns the "hop count" to network *NET#*, i.e., the number of gateways through which a pup must pass to reach *NET#*, according to the best routing information known at this point. The local (directly-connected) network is considered to be zero hops away. Current convention is that an inaccessible network is 16 hops away. **PUPNET.DISTANCE** may need to wait to obtain routing information from an Internetwork Router if *NET#* is not currently in its routing cache.

**(SORT.PUPHOSTS.BY.DISTANCE** *HOSTLIST***)** [Function]

Sorts *HOSTLIST* by increasing distance, in the sense of **PUPNET.DISTANCE**. *HOSTLIST* is a list of lists, the **CAR** of each list being a 16-bit Net/Host address, such as returned by

**ETHERHOSTNUMBER**. In particular, a list of ports ((nethost . socket) pairs) is in this format.

**(PRINTROUTINGTABLE** *TABLE SORT FILE***)** [Function]

Prints to *FILE* the current routing cache. The table is sorted by network number if *SORT* is true. *TABLE* = **PUP** (the default) prints the PUP routing table; *TABLE* = **NS** prints the NS routing table.

## 31.5.5 Miscellaneous PUP Utilities

**(SETUPPUP** *PUP DESTHOST DESTSOCKET TYPE ID SOC REQUEUE***)** [Function]

Fills in various fields in *PUP*'s header: its length (the header overhead length; assumes data length of zero), *TYPE*, *ID* (if *ID* is **NIL**, generates a new one itself from an internal 16-bit counter), destination host and socket (*DESTHOST* may be anything that **ETHERPORT** accepts; an explicit nonzero socket in *DESTHOST* overrides *DESTSOCKET*). If *SOC* is not supplied, a new socket is opened. *REQUEUE* fills the packets **EPREQUEUE** field (see above). Value of **SETUPPUP** is the socket.

**(SWAPPUPPORTS** *PUP***)** [Function]

Swaps the source and destination addresses in *PUP*. This is useful in simple packet exchange protocols, where you want to respond to an input packet by diddling the data portion and then sending the pup back whence it came.

**(GETPUPWORD** *PUP WORD#***)** [Function]

Returns as a 16-bit integer the contents of the *WORD#*th word of *PUP*'s data portion, counting the first word as word zero.

**(PUTPUPWORD** *PUP WORD# VALUE***)** [Function]

Stores 16-bit integer *VALUE* in the *WORD#*th word of *PUP*'s data portion.

**(GETPUPBYTE** *PUP BYTE#***)** [Function]

Returns as an integer the contents of the *BYTE#*th 8-bit byte of *PUP*'s data portion, counting the first byte as byte zero.

**(PUTPUPBYTE** *PUP BYTE# VALUE***)** [Function]

Stores *VALUE* in the *BYTE#*th 8-bit byte of *PUP*'s data portion.

**(GETPUPSTRING** *PUP OFFSET***)** [Function]

Returns a string consisting of the characters in *PUP*'s data portion starting at byte *OFFSET* (default zero) through the end of *PUP*.

**(PUTPUPSTRING** *PUP STR***)** [Function]

Appends *STR* to the data portion of *PUP*, incrementing *PUP*'s length appropriately.

## 31.5.6 PUP Debugging Aids

Tracing facilities are provided to allow the user to see the pup traffic that passes through **SENDPUP** and **GETPUP**. The tracing can be verbose, displaying much information about each packet, or terse, which shows a concise "picture" of the traffic.

**PUPTRACEFLG** [Variable]

Controls tracing information provided by **SENDPUP** and **GETPUP**. Legal values:

**NIL** No tracing.

**T** Every **SENDPUP** and every successful **GETPUP** call **PRINTPUP** of the pup at hand (see below).

**PEEK** Allows a concise "picture" of the traffic. For normal, non-broadcast packets, **SENDPUP** prints "**!**", **GETPUP** prints "**+**". For broadcast packets, **SENDPUP** prints "**↑**", **GETPUP** prints "*****". In addition, for packets that arrive not addressed to any socket on this machine (e.g., broadcast packets for a service not implemented on this machine), a "**&**" is printed.

**PUPIGNORETYPES** [Variable]

A list of pup types (small integers). If the type of a pup is on this list, then **GETPUP** and **SENDPUP** will not print the pup verbosely, but treat it as though **PUPTRACEFLG** were **PEEK**. This allows the user to filter out "uninteresting" pups, e.g., routine routing information pups (type 201Q).

**PUPONLYTYPES** [Variable]

A list of pup types. If this variable is non-**NIL**, then **GETPUP** and **SENDPUP** print verbosely *only* pups whose types appear on the list, treating others as though **PUPTRACEFLG** were **PEEK**. This lets the tracing be confined to only a certain class of pup traffic.

**PUPTRACEFILE** [Variable]

The file to which pup tracing output is sent by default. The file must be open. **PUPTRACEFILE** is initially **T**.

**PUPTRACETIME** [Variable]

If this variable is true, then each printout of a pup is accompanied by a relative timestamp (in seconds, with 2 decimal places) of the current time (i.e., when the **SENDPUP** or **GETPUP** was called; for incoming pups, this is not the same as when the pup actually arrived).

**(PUPTRACE** *FLG REGION***)** [Function]

Creates a window for puptracing, and sets **PUPTRACEFILE** to it. If **PUPTRACEFILE** is currently a window and *FLG* is **NIL**, closes the window. Sets **PUPTRACEFLG** to be *FLG*. If *REGION* is supplied, the window is created with that region. The window's **BUTTONEVENTFN** is set to cycle **PUPTRACEFLG** through the values **NIL**, **T**, and **PEEK** when the mouse is clicked in the window.

**(PRINTPUP** *PACKET CALLER FILE PRE.NOTE DOFILTER***)** [Function]

Prints the information in the header and possibly data portions of pup *PACKET* to *FILE*. If *CALLER* is supplied, it identifies the direction of the pup (**GET** or **PUT**), and is printed in front of the header. *FILE* defaults to **PUPTRACEFILE**. If *PRE.NOTE* is non-**NIL**, it is **PRIN1**'ed first. If *DOFILTER* is true, then if *PUP*'s type fails the filtering criteria of **PUPIGNORETYPES** or **PUPONLYTYPES**, then *PUP* is printed "tersely", i.e., as a !, +, ↑, or *, as described above.

**GETPUP** and **SENDPUP**, when **PUPTRACEFLG** is non-**NIL**, call **(PRINTPUP** *PUP* **{'GET** or **'PUT} NIL NIL T)**.

The form of printing provided by **PRINTPUP** can be influenced by adding elements to **PUPPRINTMACROS**.

**PUPPRINTMACROS** [Variable]

An association list of elements (*PUPTYPE . MACRO*) for printing pups. The *MACRO* (**CDR** of each element) tells how to print the information in a pup of type *PUPTYPE* (**CAR** of the element). If *MACRO* is a litatom, then it is a function of two arguments (*PUP FILE*) that is applied to the pup to do the printing. Otherwise, *MACRO* is a list describing how to print the data portion of the pup (the header is printed in a standard way).

The list form of *MACRO* consists of "commands" that specify a "datatype" to interpret the data, and an indication of how far that datatype extends in the packet. Each element of *MACRO* is one of the following: (a) a byte offset (positive integer), indicating the byte at which the next element, if any, takes effect; (b) a negative integer, the absolute value of which is the number of bytes until the next element, if any, takes effect; or (c) an atom giving the format in which to print the data, one of the following:

**BYTES** Print the data as 8-bit bytes, enclosed in brackets. This is the default format to start with.

**CHARS** Print the data as (8-bit) characters. Non-printing characters are printed as if the format were **BYTES**, except that the sequence 15Q, 12Q is printed specially as [crlf].

**WORDS** Print the data as 16-bit integers, separated by commas (or the current **SEPR**).

**INTEGERS** Print the data as 32-bit integers, separated by commas (or the current **SEPR**). Note: the singular **BYTE, CHAR, WORD, INTEGER** are accepted as synonyms for these four commands.

**SEPR** Set the separator for **WORDS** and **INTEGERS** to be the next element of the macro. The separator is initially the two characters, comma, space.

**IFSSTRING** Interprets the data as a 16-bit length followed by that many 8-bit bytes or characters. If the current datatype is **BYTES**, leaves it alone; otherwise, sets it to be **CHARS**.

**...** If there is still data left in the packet by the time processing reaches this command, prints "..." and stops.

**FINALLY** The next element of the macro is printed when the end of the packet is reached (or printing stops because of a ...). This command does not alter the datatype, and can appear anywhere in the macro as long as it is encountered before the actual end of the packet.

**T** Perform a **TERPRI**.

**REPEAT** The remainder of the macro is itself treated as a macro to be applied over and over until the packet is exhausted. Note that the offsets specified in the macro must be in the relative form, i.e., negative integers. For example, the macro **(INTEGERS 4 REPEAT BYTES -2 WORDS -4)** says to print the first 4 bytes of the data as one 32-bit integer, then print the rest of the data as sets of 2 8-bit bytes and 2 16-bit words.

Only as much of the macro is processed as is needed to print the data in the given packet. The default macro for printing a pup is **(BYTES 12 ...)**, meaning to print the first up to 12 bytes as bytes, and then print "..." if there is anything left.

**(PUP.ECHOUSER** *HOST ECHOSTREAM INTERVAL NTIMES***)** [Function]

Sends dummy packets to be echoed by the host *HOST*. Can be used as a simple test of the functioning of the Ethernet and the host.

*HOST* is the pup host to send the packets to. *ECHOSTREAM* is the stream for printing status information. *INTERVAL* is the interval (in milliseconds) to wait for the packet to be echoed (default 1000). *NTIMES* is the number of packets to send (default 1000).

As each packet is sent and received, characters are printed to *ECHOSTREAM* as follows:

**!** Printed when a packet is sent.

**+** Printed when an echo packet is sucessfully received.

**.** Printed when an echo packet has not been received after *INTERVAL* milliseconds.

**?** Printed when a packet is received, but it isn't an echo packet or an error packet.

**(late)** Printed when an error packet is received, after the echo request timed out.

The trace can be used to test the functioning of the ethernet and host. For example, if the trace is **!+!+!+!+!+**, the host is listening and echoing correctly. **!.!.!.!.!.** indicates that for some reason the host is not responding. **!+!.!.!(late).!(late)(late)+** indicates that the packets are being echoed, but not immediately.

The following functions are used by **PRINTPUP** and similar functions, and may be of interest in special cases.

**(PORTSTRING** *NETHOST SOCKET***)** [Function]

Converts the pup address *NETHOST*, *SOCKET* into octal string format as follows: *NET#HOST#SOCKET*. *NETHOST* may be a port (dotted pair of nethost and socket), in which case *SOCKET* is ignored, and the socket portion of *NETHOST* is omitted from the string if it is zero.

**(PRINTPUPROUTE** *PACKET CALLER FILE***)** [Function]

Prints the source and destination addresses of pup *PACKET* to *FILE* in the **PORTSTRING** format, preceded by *CALLER* (interpreted as with **PRINTPUP**).

**(PRINTPACKETDATA** *BASE OFFSET MACRO LENGTH FILE***)** [Function]

Prints data according to *MACRO*, which is a list interpreted as described under **PUPPRINTMACROS**, to *FILE*. The data starts at *BASE* and extends for *LENGTH* bytes. The actual printing starts at the *OFFSET*th byte, which defaults to zero. For example, **PRINTPUP** ordinarily calls **(PRINTPACKETDATA (fetch PUPCONTENTS of** *PUP***) 0** *MACRO* **(IDIFFERENCE (fetch PUPLENGTH of** *PUP***) 20)** *FILE***)**.

**(PRINTCONSTANT** *VAR CONSTANTLIST FILE PREFIX***)** [Function]

*CONSTANTLIST* is a list of pairs (*VARNAME VALUE*), of the form given to the **CONSTANTS** File Package Command. **PRINTCONSTANT** prints *VAR* to *FILE*, followed in parentheses by the *VARNAME* out of *CONSTANTLIST* whose *VALUE* is **EQ** to *VAR*, or **?** if it finds no such element. If *PREFIX* is non-**NIL** and is an initial substring of the selected *VARNAME*, then *VARNAME* is printed without the prefix.

For example, if **FOOCONSTANTS** is **((FOO.REQUEST 1) (FOO.ANSWER 2) (FOO.ERROR 3))**, then **(PRINTCONSTANT 2 FOOCONSTANTS T "FOO.")** produces "**2 (ANSWER)**".

**(OCTALSTRING *N*)** [Function]

Returns a string of octal digits representing *N* in radix 8.

# 31.6 NS Level One Functions

The functions in this section are used to implement level two and higher NS protocols. The packets used in the NS protocol are termed Xerox Internet Packets (XIPs). The functions for manipulating XIPs are similar to those for managing PUPs, so will be described in less detail here. The major difference is that NS host addresses are 48-bit numbers. Since Interlisp-D cannot currently represent 48-bit numbers directly as integers, there is an interim form called **NSHOSTNUMBER**, which is defined as a **TYPERECORD** of three fields, each of them being a 16-bit portion of the 48-bit number.

## 31.6.1 Creating and Managing XIPs

There is a record **XIP** that overlays the data portion of an **ETHERPACKET** and describes the format of a XIP. This record defines the following fields: **XIPLENGTH** (16 bits), **XIPTCONTROL** (transmit control, 8 bits, cleared when a XIP is transmitted), **XIPTYPE** (8 bits), **XIPDESTNET** (32 bits), **XIPDESTHOST** (an **NSHOSTNUMBER**), **XIPDESTSOCKET** (16 bits), and **XIPSOURCENET**, **XIPSOURCEHOST**, and **XIPSOURCESOCKET**, analagously. The field **XIPCONTENTS** is a pointer to the start of the data portion of the XIP.

**(ALLOCATE.XIP)** [Function]

Returns a (possibly used) XIP. As with **ALLOCATE.PUP**, the header fields are guaranteed to be zero, but there may be garbage in the data portion if the pup had been recycled.

**(RELEASE.XIP *XIP*)** [Function]

Releases *XIP* to the free pool.

### 31.6.2 NS Sockets

As with pups, XIPs are sent and received on a *socket*. The same comments apply as with pup sockets (page 31.29), except that NS socket numbers are only 16 bits.

**(OPENNSOCKET** *SKT# IFCLASH***)** [Function]

Opens a new NS socket. If *SKT#* is **NIL** (the normal case), a socket number is chosen automatically, guaranteed to be unique, and probably different from any socket opened this way in the last 18 hours. If a specific local socket is desired, as is typically the case when implementing a server, *SKT#* is given, and must be a (up to 16-bit) number. *IFCLASH* governs what to do if *SKT#* is already in use: if *IFCLASH* is **NIL**, an error is generated; if *IFCLASH* is **ACCEPT**, the socket is quietly returned; if *IFCLASH* is **FAIL**, then **OPENNSOCKET** returns **NIL** without causing an error.

**(CLOSENSOCKET** *NSOC NOERRORFLG***)** [Function]

Closes and releases socket *NSOC*. If *NSOC* is **T**, closes all NS sockets (this must be used with caution, since it will also close system sockets!). If *NSOC* is already closed, an error is generated unless *NOERRORFLG* is true.

**(NSOCKETNUMBER** *NSOC***)** [Function]

Returns the socket number (a 16-bit integer) of *NSOC*.

**(NSOCKETEVENT** *NSOC***)** [Function]

Returns the **EVENT** of *NSOC*. This event is notified whenever a XIP arrives on *NSOC*.

### 31.6.3 Sending and Receiving XIPs

**(SENDXIP** *NSOC XIP***)** [Function]

Sends *XIP* on socket *NSOC*. If any of the **XIPSOURCESHOST**, **XIPSOURCENET**, or **XIPSOURCESOCKET** fields is zero, **SENDXIP** fills them in using the NS address of this machine and/or the socket number of *NSOC*, as needed.

**(GETXIP** *NSOC WAIT***)** [Function]

Returns the next XIP that has arrived addressed to socket *NSOC*. If there are no XIPs waiting on *NSOC*, then **GETXIP** returns **NIL**, or waits for a XIP to arrive if *WAIT* is **T**. If *WAIT* is an integer, **GETXIP** interprets it as a number of milliseconds to wait, finally returning **NIL** if a XIP does not arrive within that time.

**(DISCARDXIPS** *NSOC***)** [Function]

Discards without examination any XIPs that have arrived on *NSOC* and not yet been read by a **GETXIP**.

**(EXCHANGEXIPS** *SOC OUTXIP IDFILTER TIMEOUT***)** [Function]

Useful for simple NS packet exchange protocls. Sends *OUTXIP* on *SOC*, then waits for a responding XIP, which it returns. If *IDFILTER* is true, ignores XIPs whose packet exchange ID (the first 32 bits of the data portion) is different from that of *OUTXIP*. *TIMEOUT* is the length of time (msecs) to wait for a response before giving up and returning **NIL**. *TIMEOUT* defaults to **\ETHERTIMEOUT**. **EXCHANGEXIPS** discards without examination any XIPs that are currently waiting on *SOC* before *OUTXIP* gets sent.

### 31.6.4 NS Debugging Aids

XIPs can be printed automatically by **SENDXIP** and **GETXIP** analogously to the way pups are. The following variables behave with respect to XIPs the same way that the corresponding PUP-named variables behave with respect to PUPs: **XIPTRACEFLG, XIPTRACEFILE, XIPIGNORETYPES, XIPONLYTYPES, XIPPRINTMACROS**. In addition, the functions **PRINTXIP, PRINTXIPROUTE, XIPTRACE,** and **NS.ECHOUSER** are directly analogous to **PRINTPUP, PRINTPUPROUTE, PUPTRACE,** and **PUP.ECHOUSER**. See page 31.32.

## 31.7 Support for Other Level One Protocols

Raw packets other than of type PUP or NS can also be sent and received. This section describes facilities to support such protocols. Many of these functions have a \ in their names to designate that they are system internal, not to be dealt with as casually as user-level functions.

**(RESTART.ETHER)** [Function]

This function is intended to be invoked from the executive on those rare occasions when the Ethernet appears completely unresponsive, due to Lisp having gotten into a bad state. **RESTART.ETHER** reinitializes Lisp's Ethernet driver(s), just as when the Lisp system is started up following a **LOGOUT, SYSOUT,** etc. This aborts any Ethernet activity and clears several internal caches, including the routing table.

**(\ALLOCATE.ETHERPACKET)** [Function]

Returns an **ETHERPACKET** datum. Enough of the packet is cleared so that if the packet represents a **PUP** or **NS** packet, that its header is all zeros; no guarantee is made about the remainder of the packet.

**(\RELEASE.ETHERPACKET** *EPKT***)** [Function]

Returns *EPKT* to the pool of free packets. This operation is dangerous if the caller actually is still holding on to *EPKT*, e.g., in some queue, since this packet could be returned to someone else (via **\ALLOCATE.ETHERPACKET**) and suffer the resulting contention.

From a logical standpoint, programs need never call **\RELEASE.ETHERPACKET**, since the packets are eventually garbage-collected after all pointers to them drop. However, since the packets are so large, normal garbage collections tend not to occur frequently enough. Thus, for best performance, a well-disciplined program should explicitly release packets when it knows it is finished with them.

A locally-connected network for the transmission and receipt of Ether packets is specified by a *network descriptor block*, an object of type **NDB**. There is one **NDB** for each directly-connected network; ordinarily there is only one. The **NDB** contains information specific to the network, e.g., its **PUP** and **NS** network numbers, and information about how to send and receive packets on it.

**\LOCALNDBS** [Variable]

The first **NDB** connected to this machine, or **NIL** if there is no network. Any other **NDB**s are linked to this first one via the **NDBNEXT** field of the **NDB**.

In order to transmit an Ether packet, a program must specify the packet's type and its immediate destination. The type is a 16-bit integer identifying the packet's protocol. There are preassigned types for **PUP** and **NS**. The destination is a host address on the local network, in whatever form the local network uses for addressing; it is not necessarily related to the logical ultimate destination of the packet. Determining the immediate destination of a packet is the task of *routing*. The functions **SENDPUP** and **SENDXIP** take care of this for the **PUP** and **NS** protocols, routing a packet directly to its destination if that host is on the local network, or routing it to a gateway if the host is on some other network accessible via the gateway. Of course, a gateway must know about the type (protocol) of a packet in order to be able to forward it.

**(ENCAPSULATE.ETHERPACKET** *NDB PACKET PDH NBYTES ETYPE***)** [Function]

Encapsulates *PACKET* for transmission on network *NDB*. *PDH* is the physical destination host (e.g., an 8-bit pup host number or a 48-bit NS host number); *NBYTES* is the length of the packet in bytes; *ETYPE* is the packet's encapsulation type (an integer).

**(TRANSMIT.ETHERPACKET** *NDB PACKET***)** [Function]

Transmits *PACKET*, which must already have been encapsulated, on network *NDB*. Disposition of the packet after transmission is complete is determined by the value of *PACKET*'s **EPREQUEUE** field.

In order to receive Ether packets of type other than **PUP** or **NS**, the programmer must specify what to do with incoming packets. Lisp maintains a set of ***packet filters***, functions whose job it is to appropriately dispose of incoming packets of the kind they want. When a packet arrives, the Ethernet driver calls each filter function in turn until it finds one that accepts the packet. The filter function is called with two arguments: (*PACKET TYPE*), where *PACKET* is the actual packet, and *TYPE* is its Ethernet encapsulation type (a number). If a filter function accepts the packet, it should do what it wants to with it, and return **T**; else it should return **NIL**, allowing other packet filters to see the packet.

Since the filter function is run at interrupt level, it should keep its computation to a minimum. For example, if there is a lot to be done with the packet, the filter function can place it on a queue and notify another process of its arrival.

The system already supplies packet filters for packets of type **PUP** and **NS**; these filters enqueue the incoming packet on the input queue of the socket to which the packet is addressed, after checking that the packet is well-formed and indeed addressed to an existing socket on this machine.

Incoming packets have their **EPNETWORK** field filled in with the **NDB** of the network on which the packet arrived.

**(\ADD.PACKET.FILTER** *FILTER***)** [Function]

Adds function *FILTER* to the list of packet filters if it is not already there.

**(\DEL.PACKET.FILTER** *FILTER***)** [Function]

Removes *FILTER* from the list of packet filters.

**(\CHECKSUM** *BASE NWORDS INITSUM***)** [Function]

Computes the one's complement add and cycle checksum for the *NWORDS* words starting at address *BASE*. If *INITSUM* is supplied, it is treated as the accumulated checksum for some set of words preceding *BASE*; normally *INITSUM* is omitted (and thus treated as zero).

**(PRINTPACKET** *PACKET CALLER FILE PRE.NOTE DOFILTER***)** [Function]

Prints *PACKET* by invoking a function appropriate to *PACKET*'s type. See **PRINTPUP** for the intended meaning of the other arguments. In order for **PRINTPACKET** to work on a non-standard packet, there must be information on the list **\PACKET.PRINTERS**.

**\PACKET.PRINTERS** [Variable]

An association list mapping packet type into the name of a function for printing that type of packet.

## 31.8 The SYSQUEUE mechanism

The **SYSQUEUE** facility provides a low-level queueing facility. The functions described herein are all system internal: they can cause much confusion if misused.

A **SYSQUEUE** is a datum containing a pointer to the first element of the queue and a pointer to the last; each item in the queue points to the next via a pointer field located at offset 0 in the item (its **QLINK** field in the **QABLEITEM** record). A **SYSQUEUE** can be created by calling **(NCREATE 'SYSQUEUE)**.

**(\ENQUEUE** *Q ITEM***)** [Function]

Enqueues *ITEM* on *Q*, i.e., links it to the tail of the queue, updating *Q*'s tail pointer appropriately.

**(\DEQUEUE** *Q***)** [Function]

Removes the first item from *Q* and returns it, or returns **NIL** if *Q* is empty.

**(\UNQUEUE** *Q ITEM NOERRORFLG***)** [Function]

Removes the *ITEM* from *Q*, wherever it is located in the queue, and returns it. If *ITEM* is not in *Q*, causes an error, unless *NOERRORFLG* is true, in which case it returns **NIL**.

**(\QUEUELENGTH** *Q***)** [Function]

Returns the number of elements in *Q*.

**(\ONQUEUE** *ITEM Q***)** [Function]

True if *ITEM* is an element of *Q*.

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**C**

## E

## G

**Q**



**R**

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